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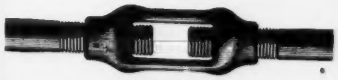

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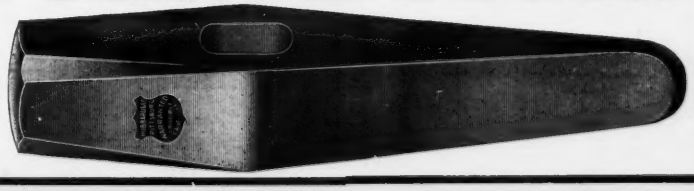

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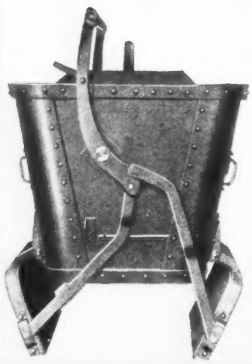

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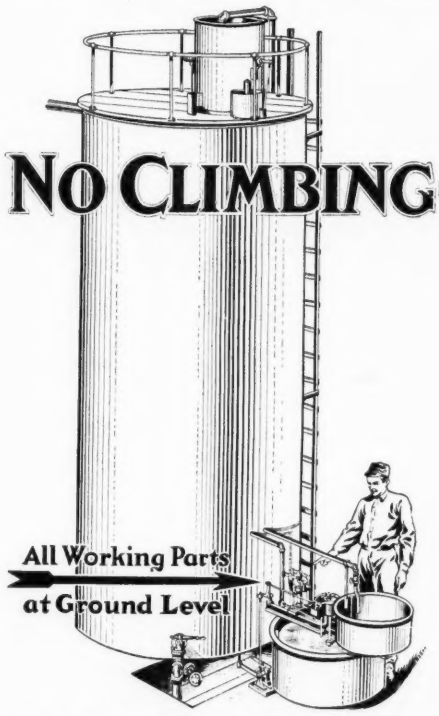

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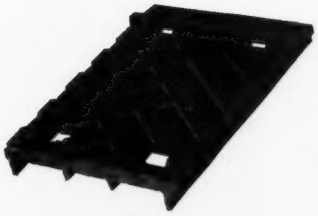

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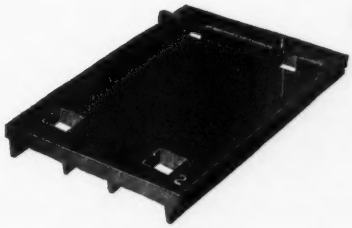

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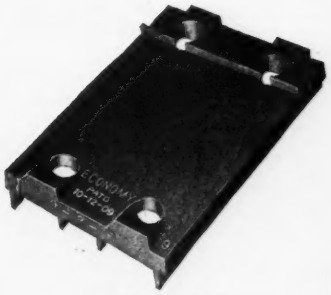

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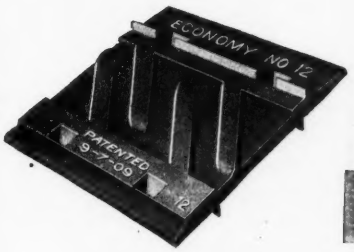

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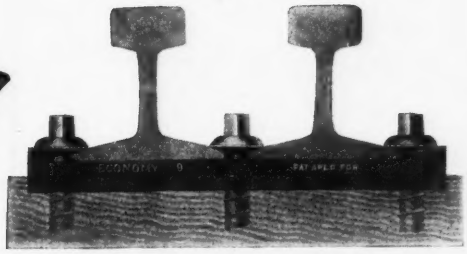

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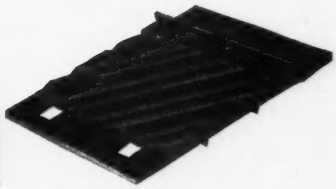

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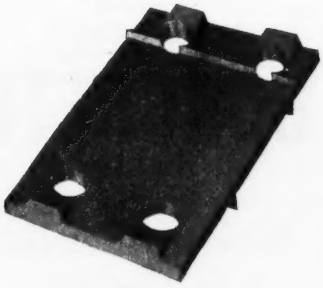

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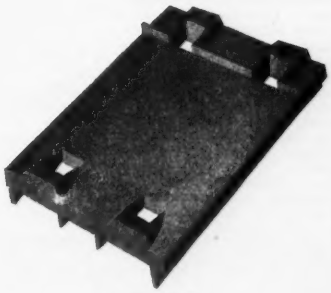

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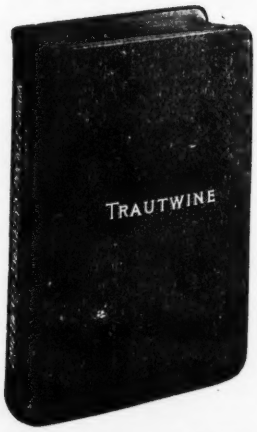

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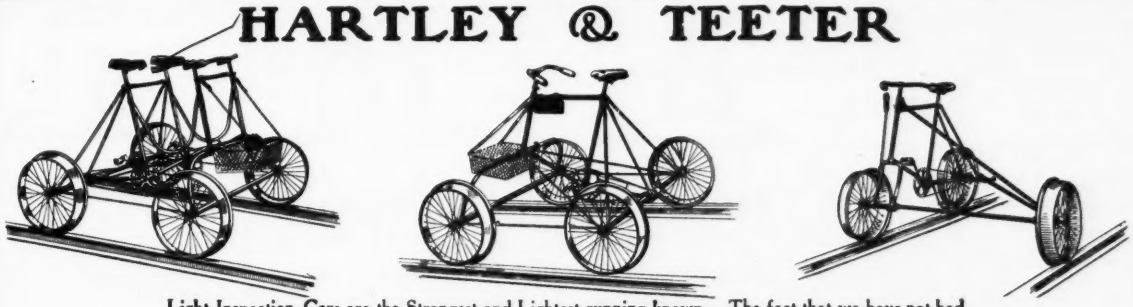

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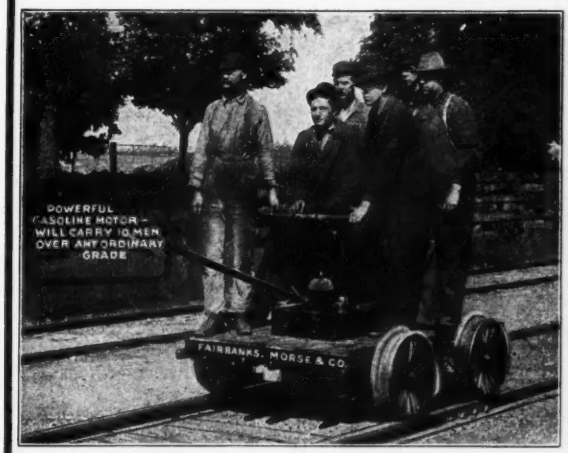

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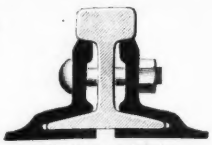

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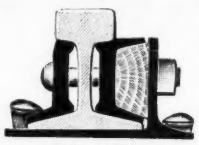

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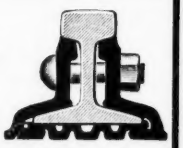

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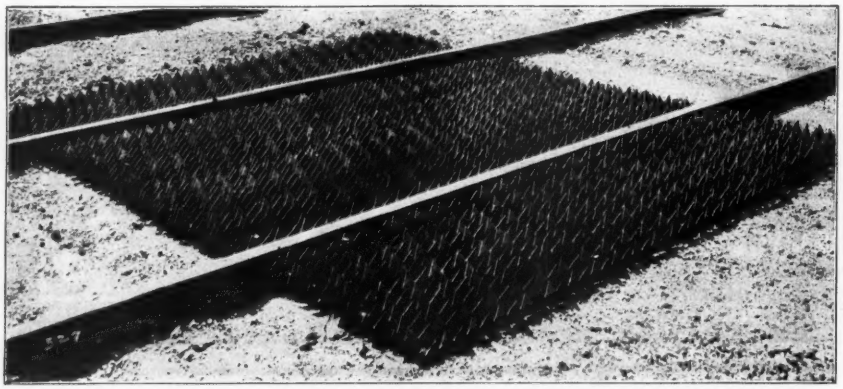

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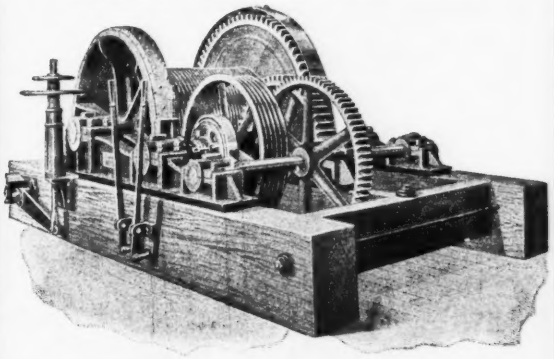

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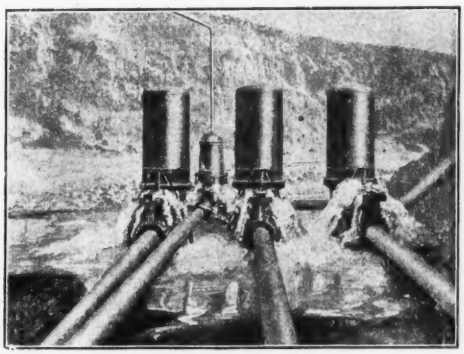

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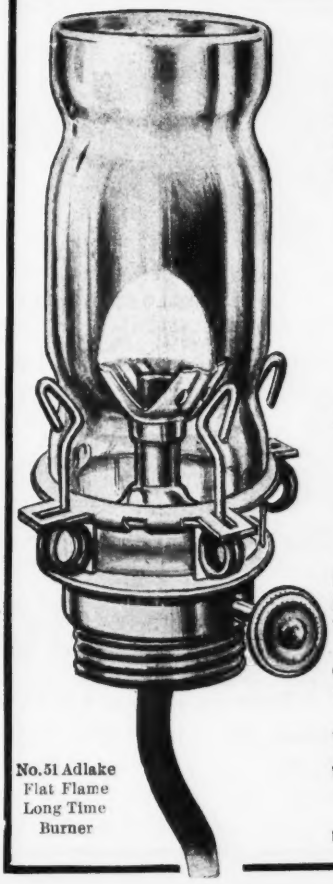

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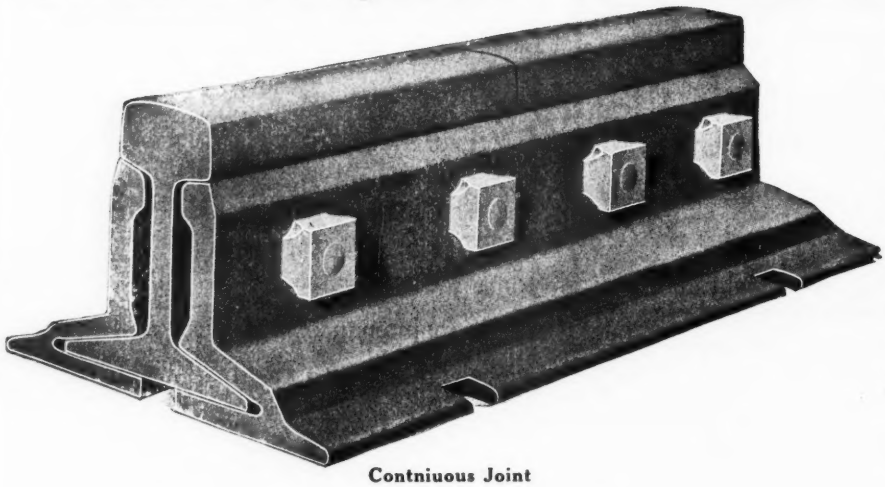

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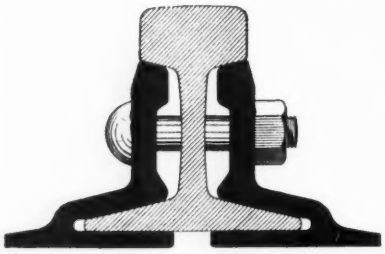

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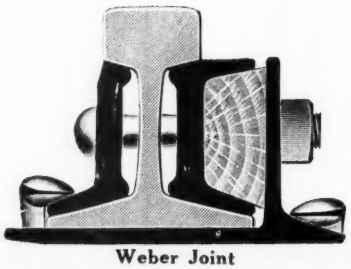

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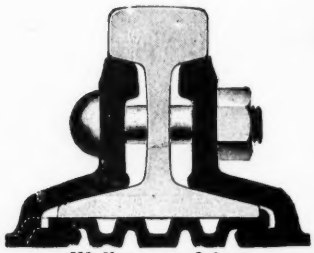

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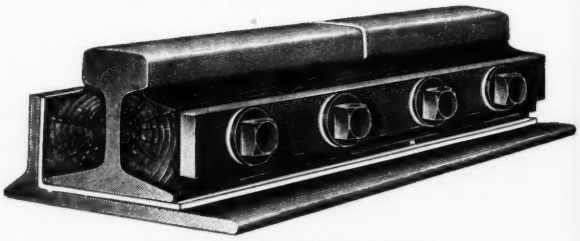

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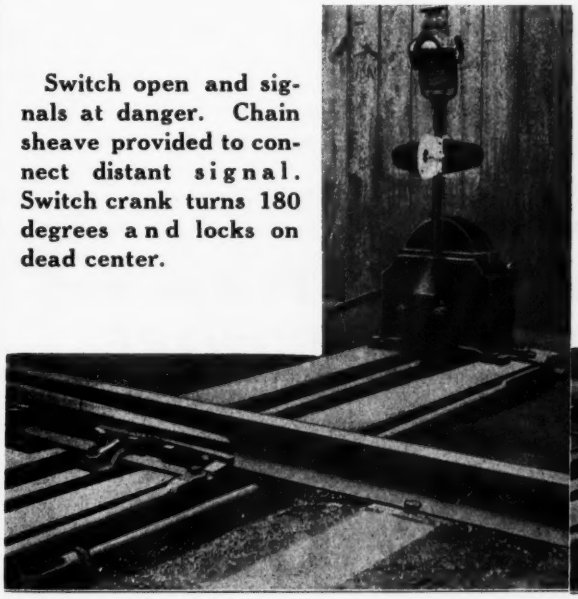
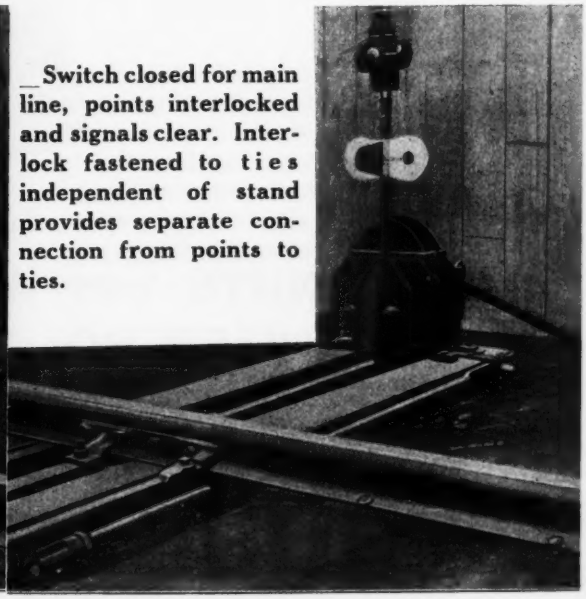
Cars can be switched on the main line and the distanct signal held at danger for protection by moving the lever from one side to the vertical.

The interlock is fastened to the ties independent of the stand and provides a separate connection from the points to the ties. If the stand is destroyed the interlock will hold the points. By placing the front rod below the top of ties the interlock will hold the main line point if the switch connections are dragged out.

The Foster Interlocking Switch Stand has been in service since August 1908 and has operated so perfectly that I am willing to furnish them on approval.



Switch open and signals at danger. Chain sheave provided to connect distant signal. Switch crank turns 180 degrees and locks on dead center.



Switch closed for main line, points interlocked and signals clear. Interlock fastened to ties independent of stand provides separate connection from points to ties.

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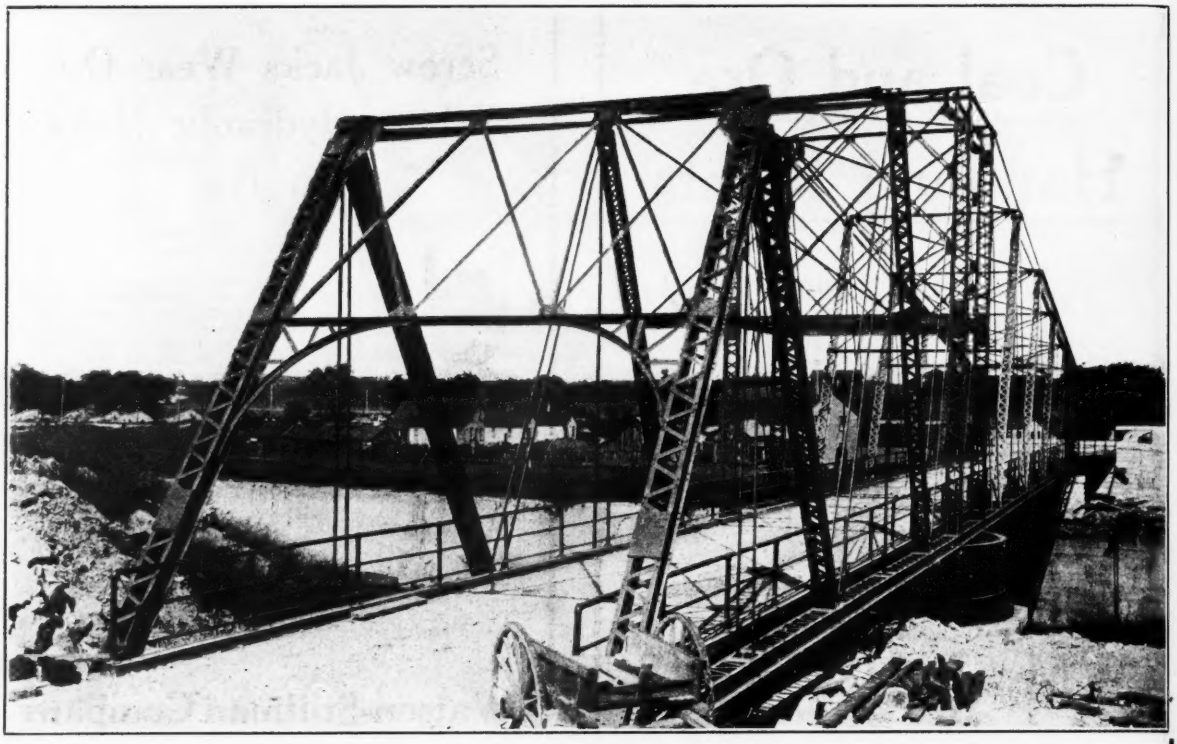

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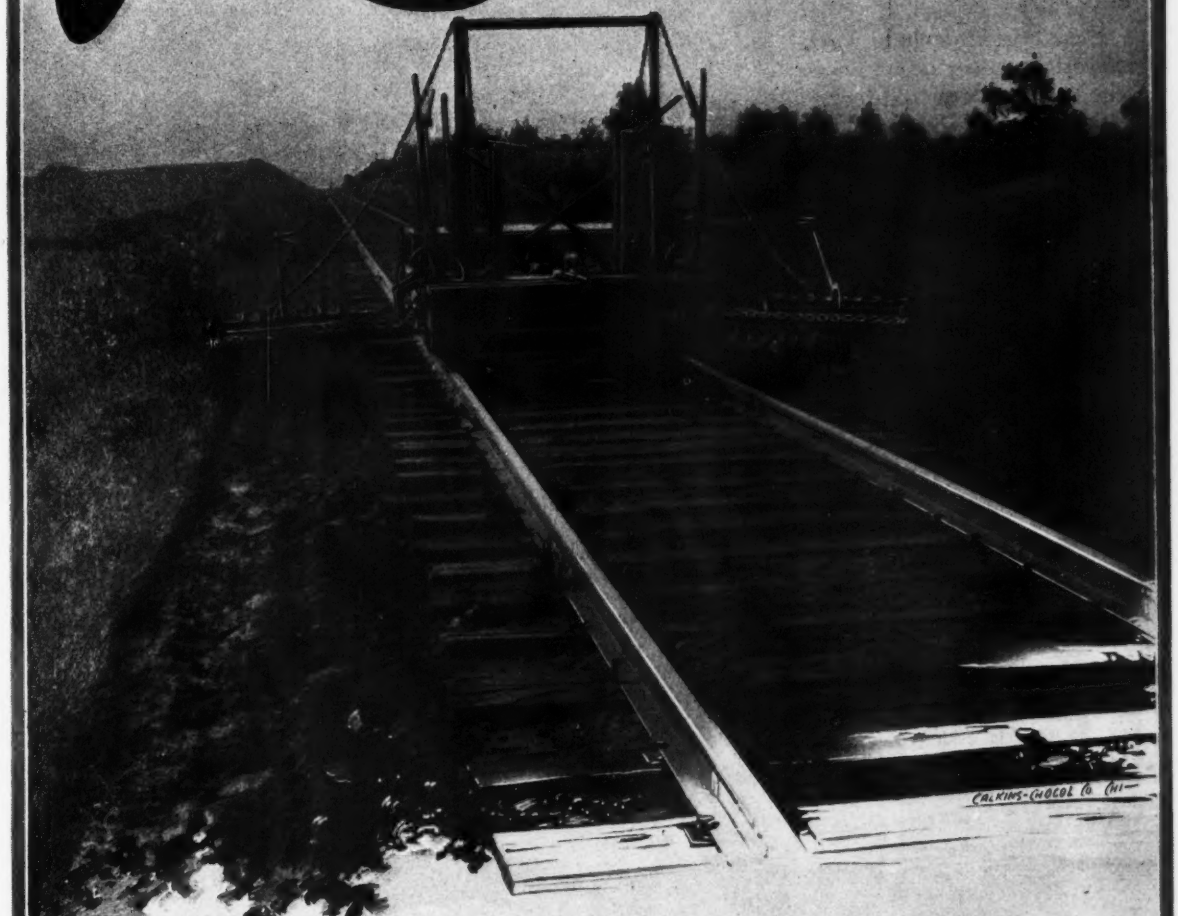

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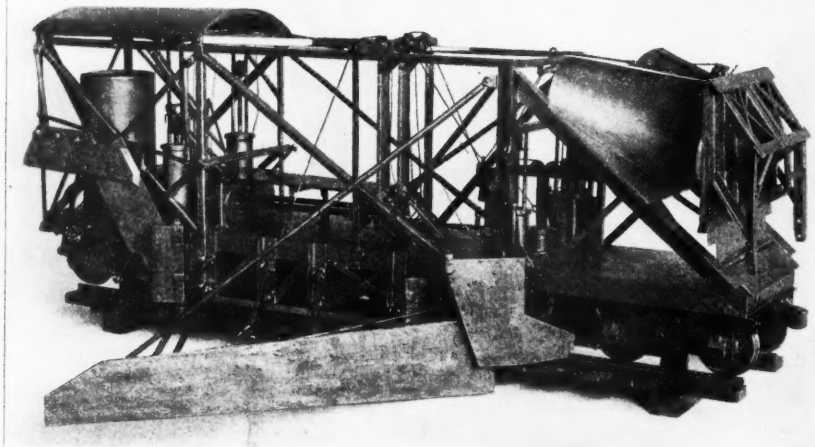
THE MANN No. 3 SPREADER, BANK SHAPER, FOLDING SNOW PLOW, BANK BUILDER

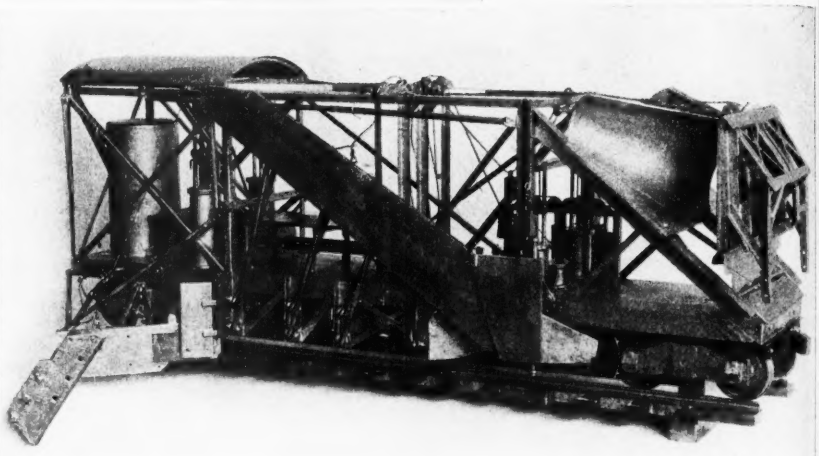


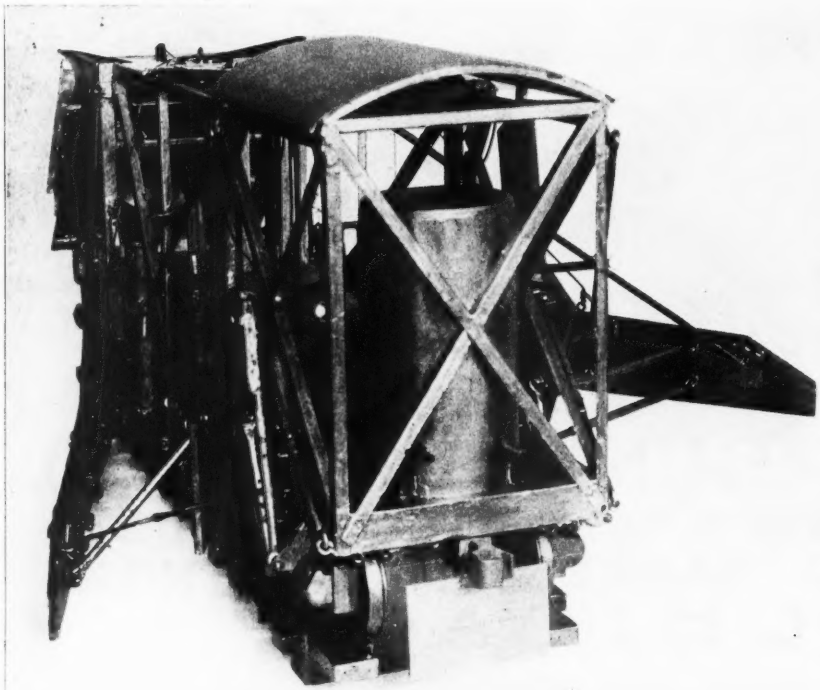
Main wing down to spread level at 24 inches below top of rail, adjustable to spread level at any desired height up to 12 inches above top of rail; also to slope up or down out from end of tie any distance not exceeding 19 feet.

Operated from platform directly in front of air reservoir by opening two air cocks both wings locked down automatically.

Bank Shaper down to working position. Any desired cross section can be formed from end of tie out 5 feet and down side of bank any distance not exceeding 4 feet at any angle, forming a true top surface shoulder and side surface. Good for cutting weeds, filling in gullies, shaping banks, etc. Operated by one air cock, can be put in or taken out of service in ten seconds.

Costs less than $1.90 per mile to finish up track on both sides with this shaper.



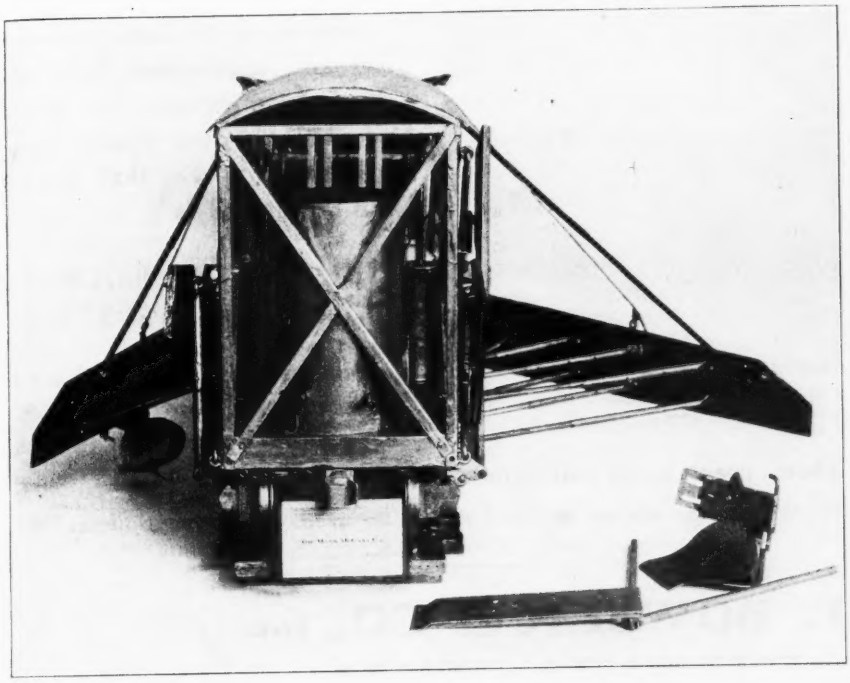


By running the machine backward all grade building or ballast material deposited beside the track is carried between the rails, which then passes under and between wings, and the surplus carried out by ballast spreader wings and deposited outside of rail on end of ties.

Ties can then be raised up through and tamped, and operation repeated until desired track elevation is secured.

BALLAST SPREADER, GRADE ELEVATOR, DITCHER AND FLANGER

PATENT APPLIED FOR

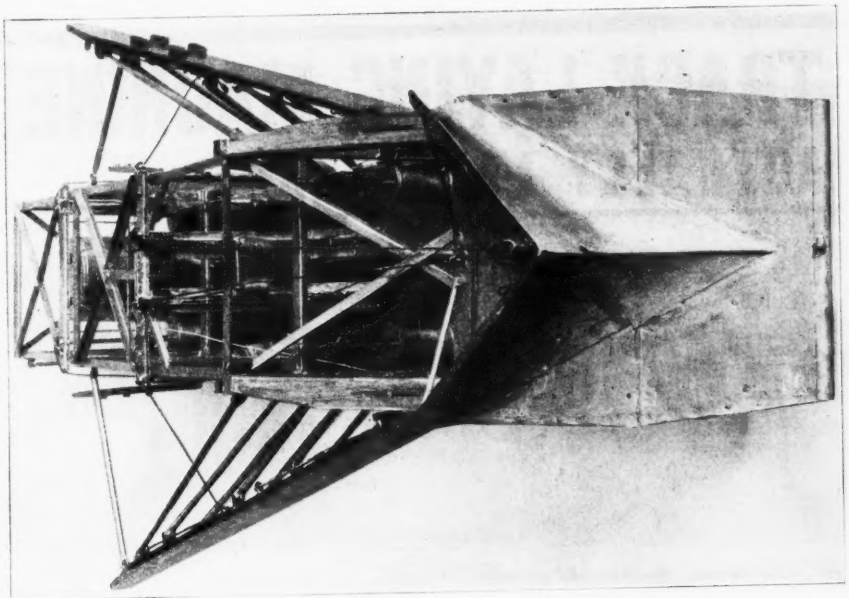


Left wing shows 24 inch plow attached to plow a furrow 4 feet out from end of tie; can be set to throw a furrow in or out.

This plow can be run directly ahead of bank shaper, forming a path for wing extension, throwing material up and in toward end of ties; the bank shaper following immediately after leveling out again and forming a true surface on top and down side of bank.

Can be operated in ten seconds.

The plows can be used for ditching cuts, which will save shimming up tracks in winter and spring where wet spots have formed, owing to slides, etc.



Folding Snow Plow down to working position, front view.

The main wing shown in cut will widen out snow cuts 16 feet wide, 15 feet above top of rail or wider in lower positions.

Wings can be lowered to level position 1 inch above top of rail, in which position a track on either side can be cleared of snow.

Yards can be cleared of snow by pushing it to one side until it is carried over all tracks and out in small yards, or piling it up from both directions where yards are too wide.

This is a universal machine that can be used to advantage every month in the year. The bank shaper will finish up a road bed on both sides of the track much better than a highway grader can. A railway is nothing more nor less than a highway with ties and iron, it and this heavy machine running on rails must of necessity do better work.

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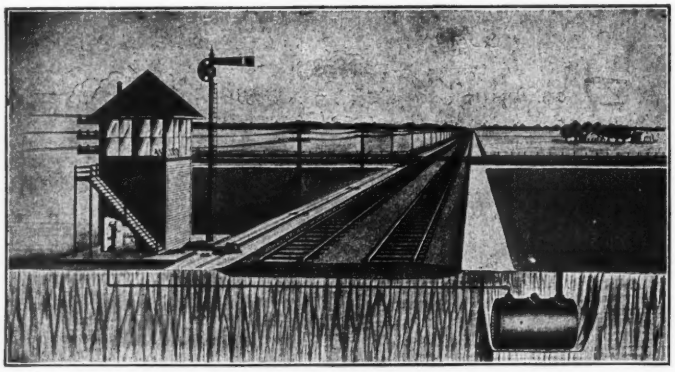

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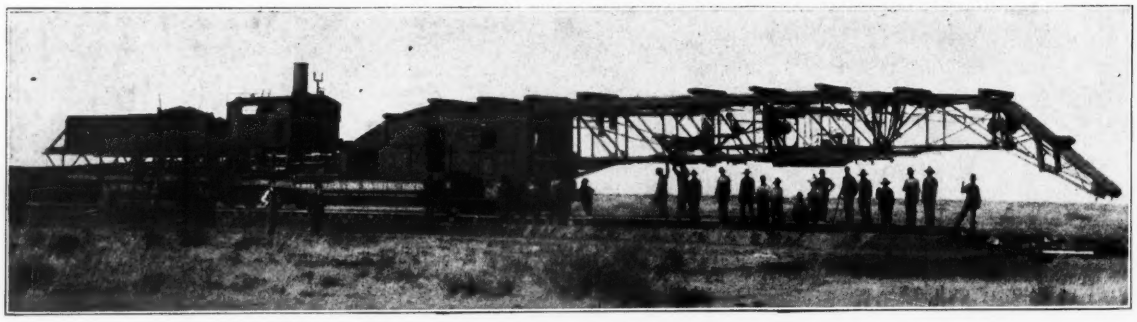

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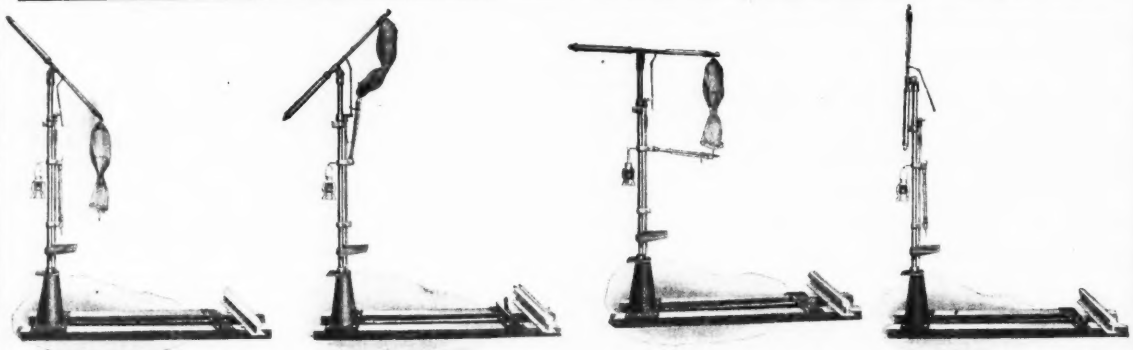
ENGINEERS		TRAINMEN		TRAINMEN IN YARDS		YARD TRAINMEN		OTHER EMPLOYES		TOTAL	
Killed	Injured	Killed	Injured	Killed	Injured	Killed	Injured	Killed	Injured	Killed	Injured
1	26	6	96	1	8	0	1	0	4	8	135



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Type B for rail up to 80 lbs.	if not over 5 inches high	50 Ton Locomotive	3¼ inches	110
Type A for rail up to 100 lbs.	if not over 5½ inches high	80 Ton Locomotive	3½ inches	145
Type Z for rail up to 100 lbs.	if not over 6 inches high	100 Ton Locomotive	3½ inches	165

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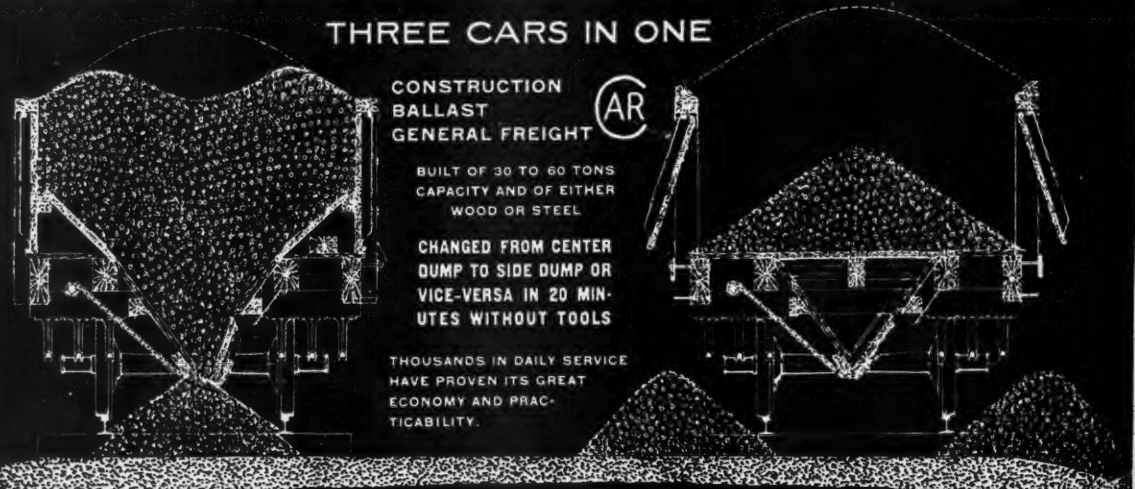
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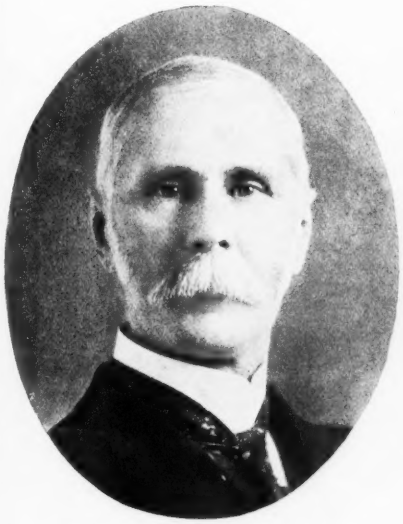

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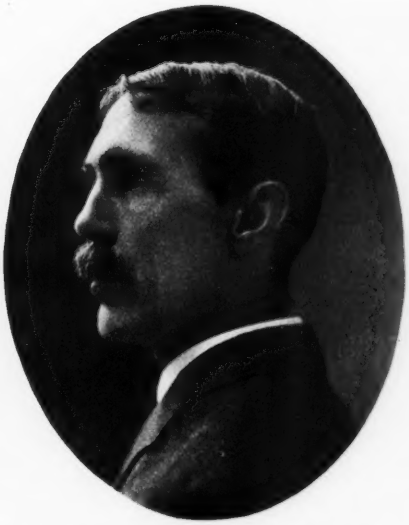

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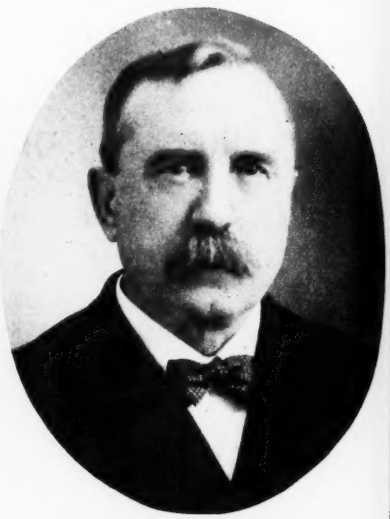

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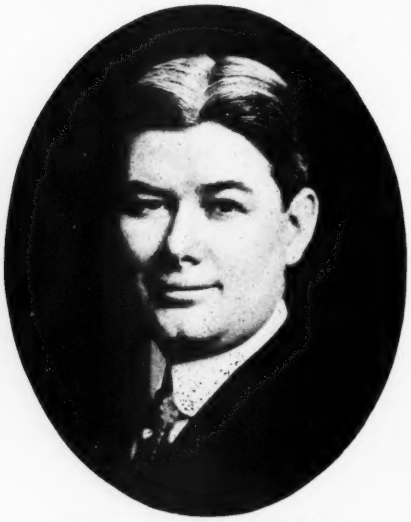

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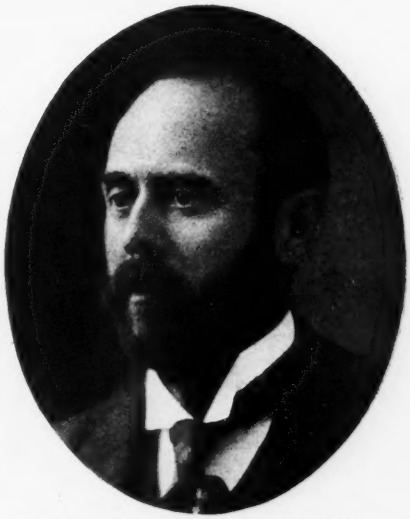

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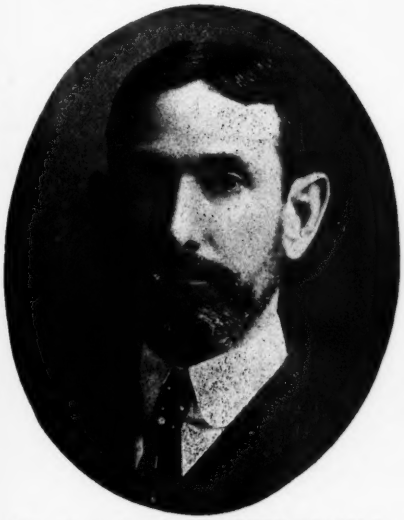

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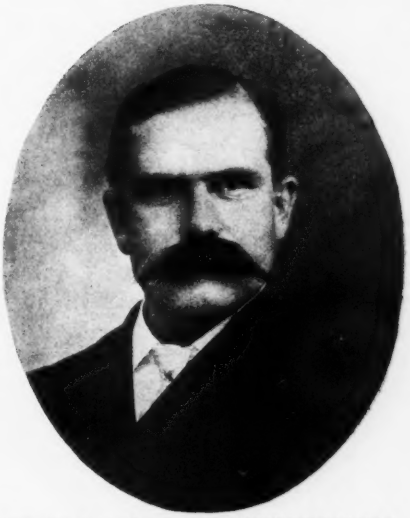

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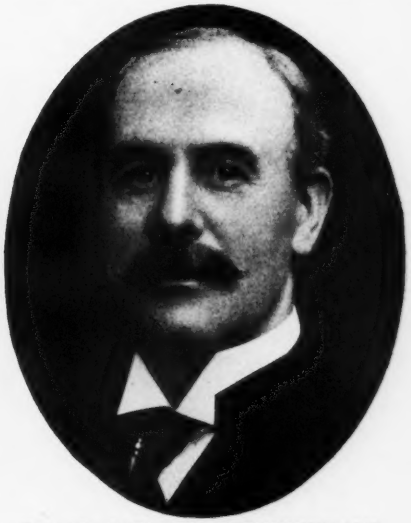

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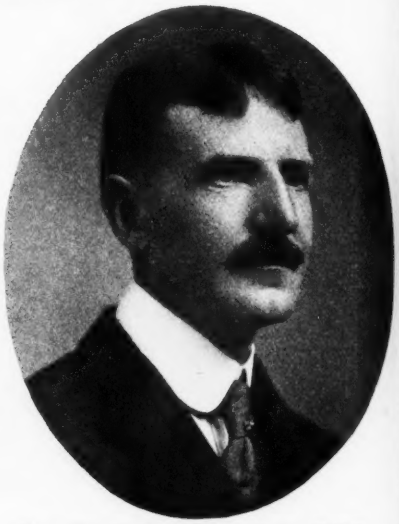

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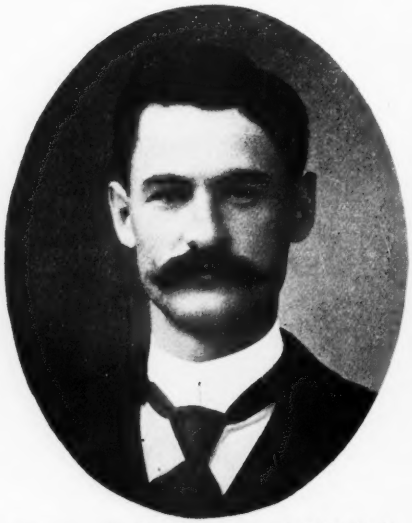

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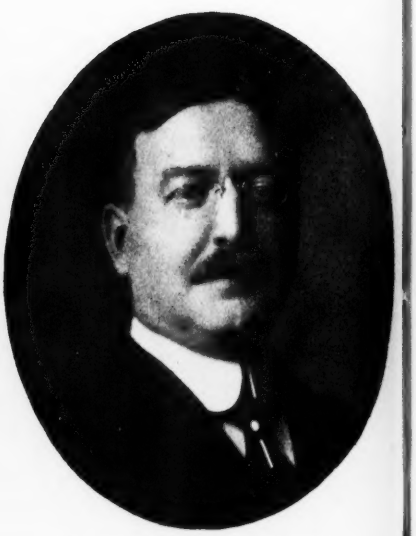

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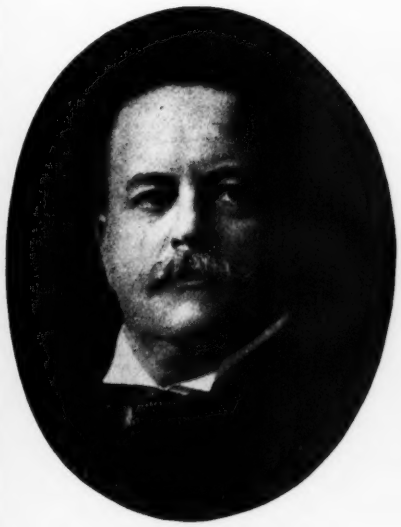

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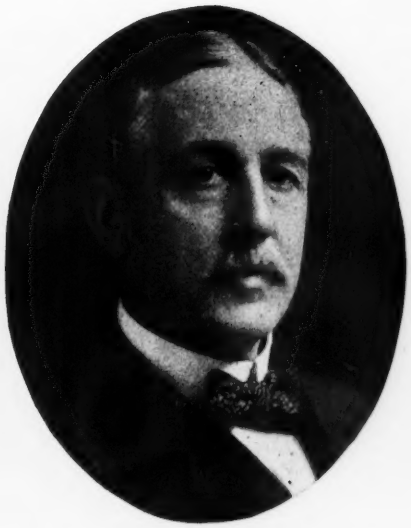

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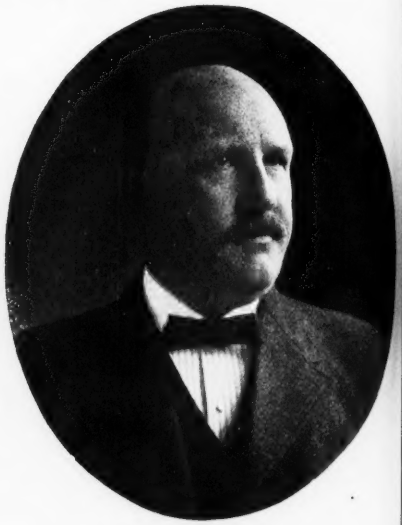

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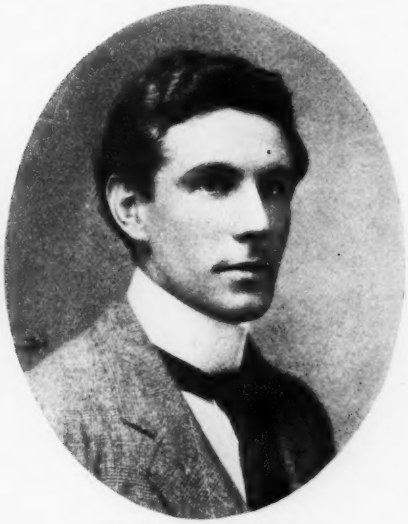

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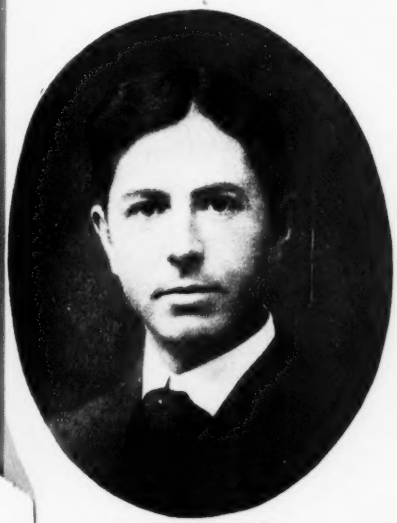

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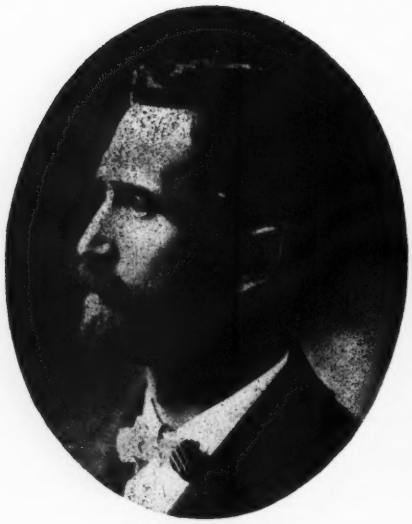

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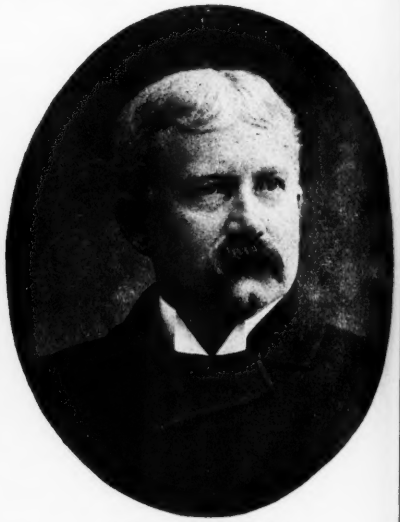

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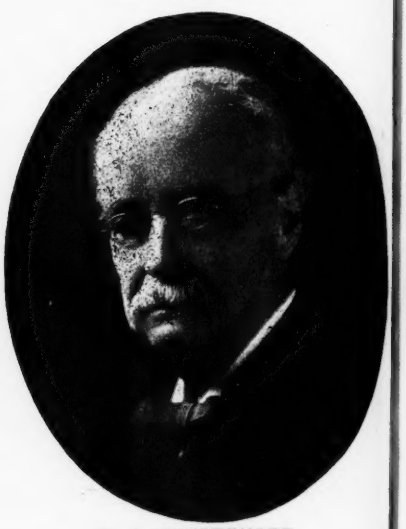

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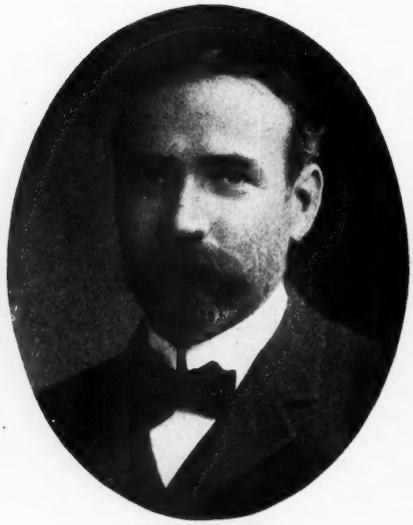
ARTHUR MONTZHEIMER,
Chf. Engr., E. J. & E. Ry.



F. L. STUART,
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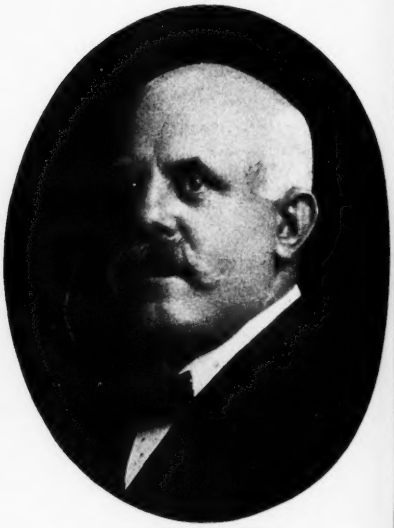

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Chf. Engr., Bessemer & L. E. R. R.

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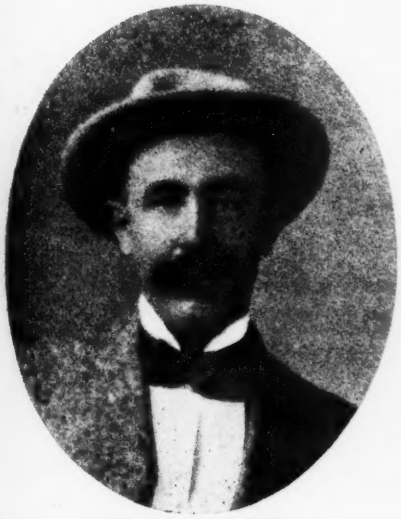
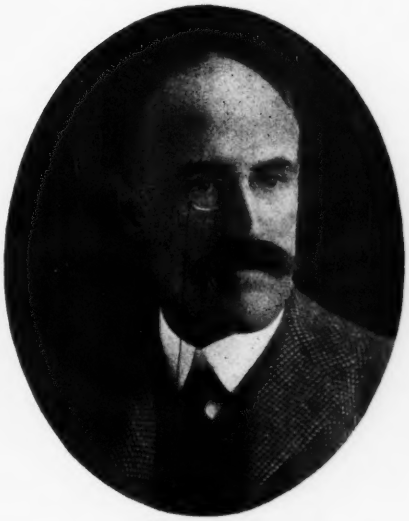
H. W. COWAN,
Chf. Engr., Colo. & Sou. Ry.

H. FERNSTROM,
Chf. Engr., Va. Ry.



M. J. BURGDORF,
Chf. Engr., F. & C. C. R. R.



W. F. TYE,
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JOS. T. RICHARDS,
Chf. Engr., M. of W., P. R. R.

W. C. SMITH,
Chf. Engr. M. of W., Nor. Pac. Ry.

M. L. BYERS,
Chf. Engr. M. of W., Mo. Pac. Ry.

GEO. F. MORSE,
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Engr. M. of W., "Soo Line."

EDWARD LAAS.
Engr. M. of W., C. M. & St. P. Ry.

C. H. EWING,
Engr. M. of W., Phil. & Read. Ry.

R. G. KENLY,
Engr. M. W. & S., M. & St. L. R. R., Ia. C. R. R.

GEO. H. HARROLD,
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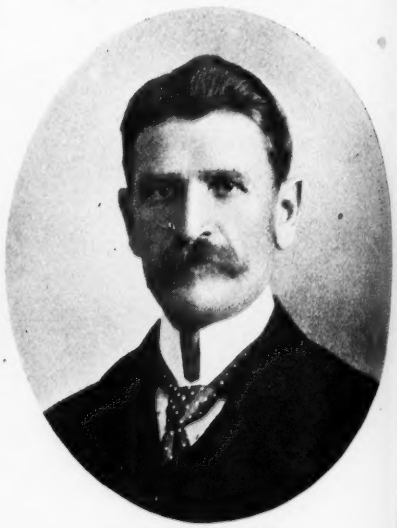
C. DOUGHERTY,
Engr. M. W., Q. & C. Route.

EDW. GRAY,
Engr. M. W., Southern Ry.



M. S. BLAIKLOCK,
Engr. M. W., Gr. Tr. Ry.

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Engr. M. W., Southern Ry.

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Engr. Grade Cross., Erie R. R.

J. T. FRAME,
Engr. M. W., C. Gr. West. R. R.

C. H. STEIN,
Engr. M. W., Centr. R. R. of N. J.

JOHN B. RUSSELL,
Engr. of Consts., B. & A. R. R.

JAMES BURKE,
Engr. M. of W., Erie R. R.

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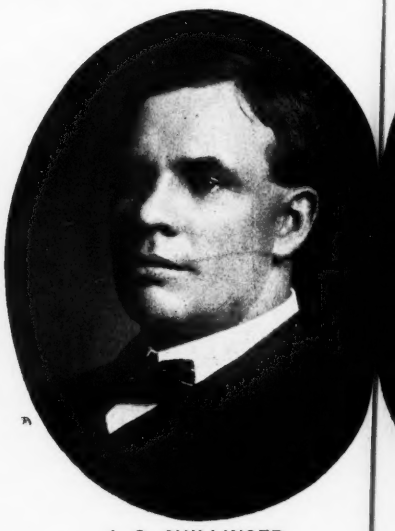
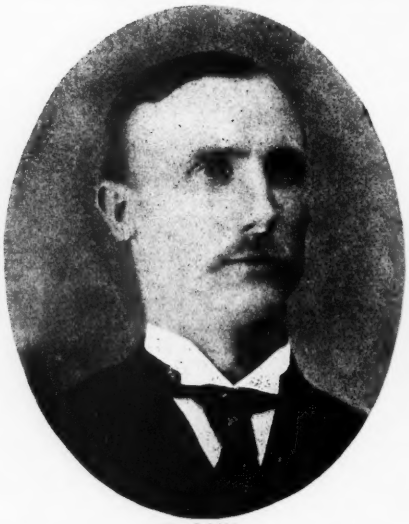
Supvr. Eng., O. S. L. R. R.

WALLACE FRANKLIN,
Sec. & Asst. Treas., G. R. G. H. & M. Ry.



J. G. SHILLINGER,
Eng. M. of W., C. C. C. & St. L. Ry.

T. C. BURPEE,
Eng. M. of W., Intercolonial Ry. of Can.



P. CAIN,
Engr. M. of W., Western Maryland Ry.

E. BEN CARTER,
Supt. M. of W., Fla. E. Coast Ry.

J. C. BEYE,
Loc. Eng., Rock Island Lines.

W. H. FINLEY,
Asst. Ch. Engr., C. & N. W. Ry.

J. G. SULLIVAN,
Asst. Ch. Engr., Can. Pac. Ry.

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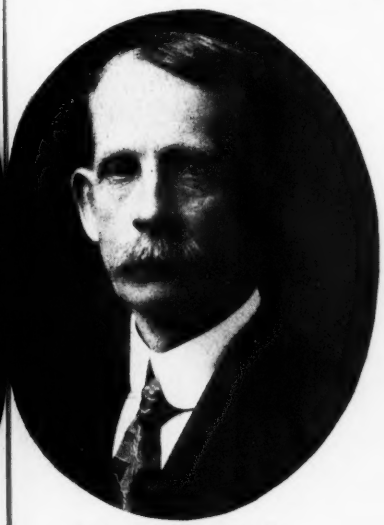

C. H. CHAMBERLAIN,
Asst. Ch. Engr., Tex. & Pac. Ry.

L. A. DOWNS,
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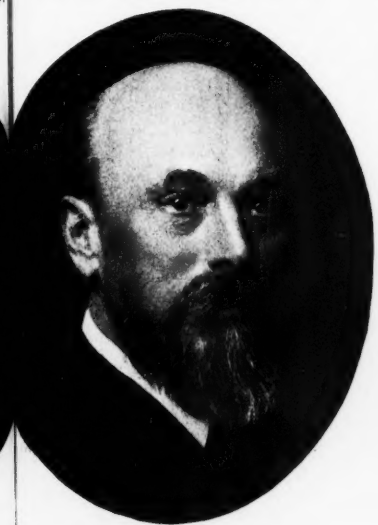
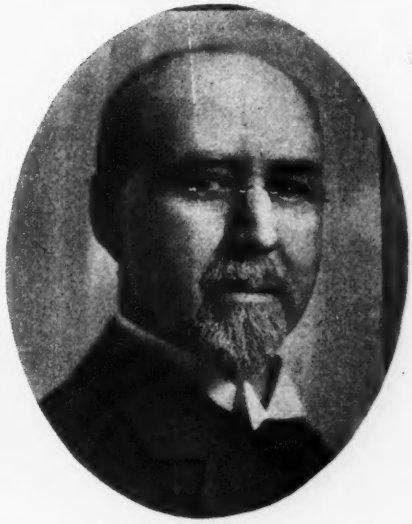
F. L. PARADIS,
Dist. Eng., N. Y. C. & H. R. R. R.



M. D. RHAME,
Dist. Engr., C. M. & St. P. Ry.

J. R. CAMERON,
Gen. Supt., Can. Nor. Ry.



W. L. WEBB,
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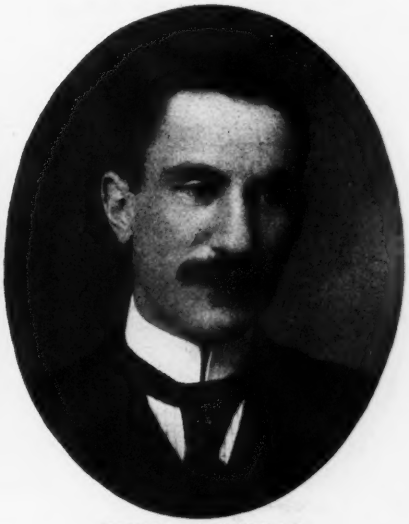
Asst. Chf. Engr., Can. Pac. R. R.

J. M. MEADE,
Engr. East Lines, A. T. & S. F. Ry.



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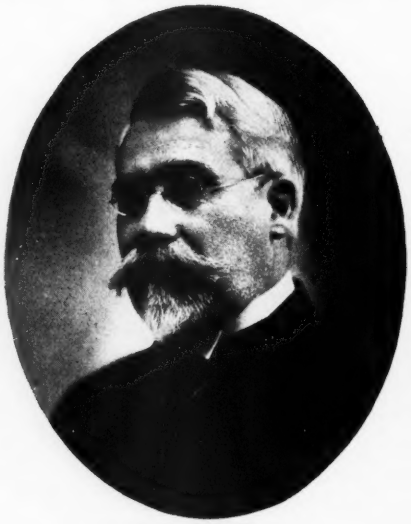
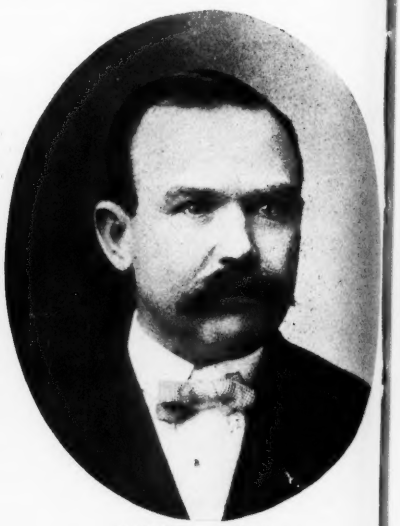
F. M. BISBEE,
Engr., A. T. & S. F. Western Lines.



J. C. BLAND,
Engr. Bldg., Penn. Lines W. of P.



EDGAR E. BALL,
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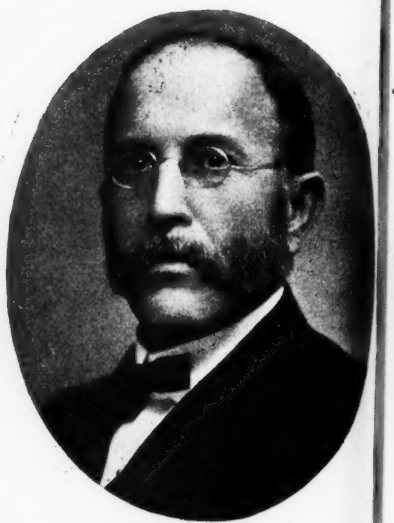
A. F. ROBINSON,
Bridge Engr., A. T. & S. F. Ry.

J. J. HARDING,
Engr. B. & B., C. M. & St. P. Ry.



FRED. E. SCHALL,
Bridge Engr., Lehigh Valley R. R.

H. R. LEONARD,
Engr. of B. & B., P. R. R.

H. E. HALE,
Engr. of Design, Mo. Pac. Sys.

H. IBSEN,
Bridge Engr., Mich. Cent. R. R.

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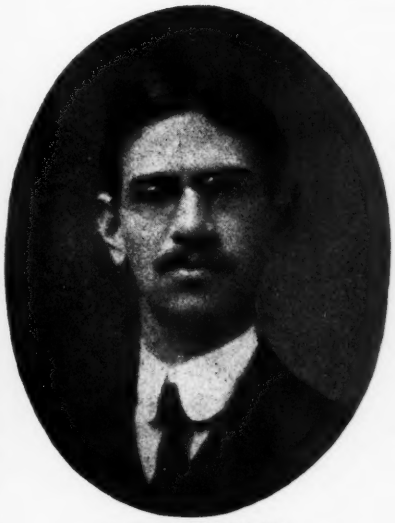

A. W. CARPENTER,
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R. E. GANT,
Engr. B. & B., I. C. R. R.

C. N. MONSARRAT,
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C. A. DUNHAM,
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R. E. TROUT,
Sig. Engr., St. L. & S. F. R. R.

E. W. NEWCOMB,
Sig. Engr., O. S. L. R. R., S. P. Lines E. of Sparks.

H. S. BALLIETT,
Sig. Engr., N. Y. C. & H. R. R. R., Pres. Ry. Sig. Assn.

H. J. FOALE,
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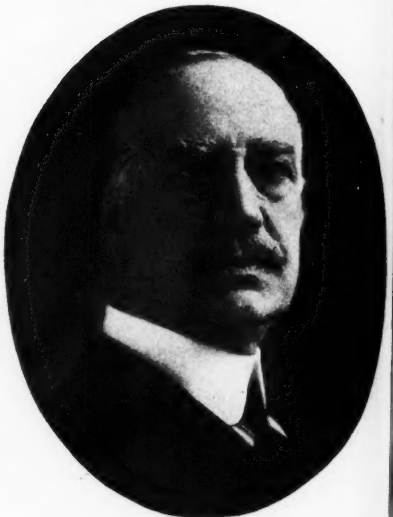
T. N. CHARLES,
Sig. Engr., C. N. O. & T. P. Ry.

C. A. CHRISTOFFERSON,
Sig. Engr., Nor. Pac. Ry.

C. J. KELLOWAY,
Sig. Engr., Atl. C. L. Ry.



W. McC. GRAFTON.
Sig. Engr., Penn. Lines & Vandalia R. R.

WM. N. MANUEL,
Supt. Sig., G. R. & I. Ry.

E. T. AMBACH,
Sig. Engr., C. H. & D. Ry.

JAMES C. YOUNG,
Sig. Engr., Union Pac. R. R.

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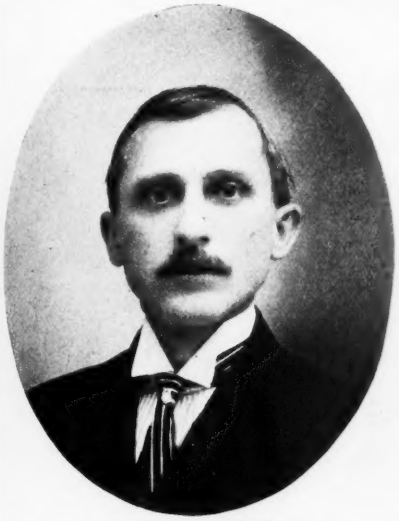

CHAS. STEVENS,
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W. J. McWAIN,
Sig. Engr., Pere Marquette R. R.

E. P. PATENALL,
Sig. Engr., B. & O. R. R.

J. B. LATIMER,
Sig. Engr., C. B. & Q. Ry.

W. H. ELLIOTT,
Sig. Engr. of Const., N. Y. C. & H. R. R. R.

B. M. McDONALD,
Div. Engr., N. Y. C. & H. R. R. R.

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Div. Engr., Erie R. R.

W. W. GAFFIN,
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H. RETTINGHOUSE,
Div. Engr., C. & N. W. Ry.

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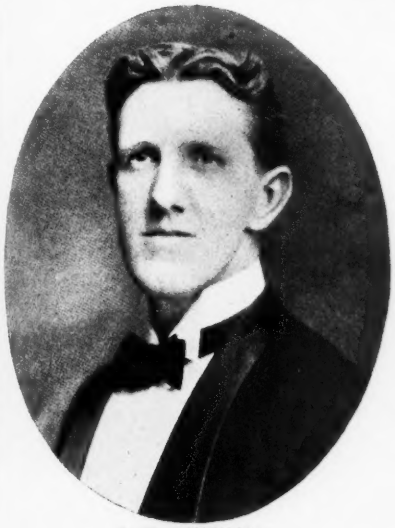

C. E. LINDSAY,
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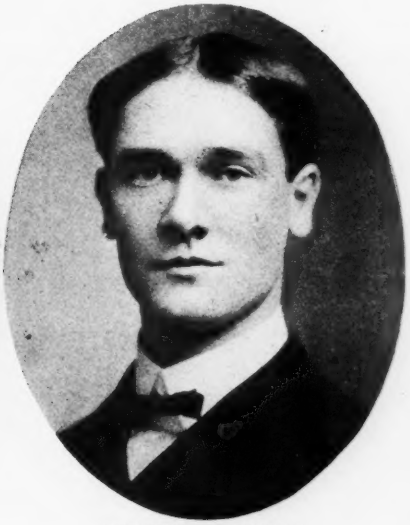
EVAN T. REISLER,
Div. Engr., Lehigh Valley R. R.

GEO. D. BROOKE,
Div. Engr., B. & O. R. R.

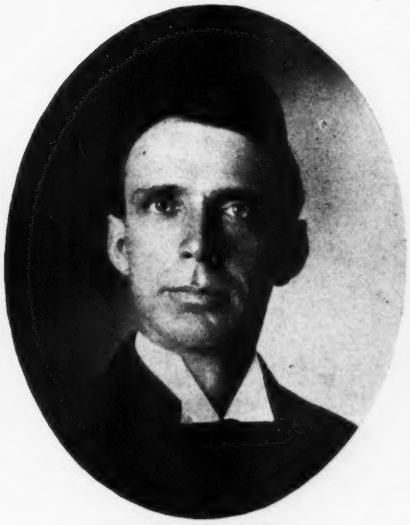
D. L. SOMMERVILLE,
Div. Engr., N. Y. C. & H. R. R. R.

R. J. GATEWOOD,
Div. Engr., A. T. & S. F. Ry.



RAYMOND C. SMITH,
Res. Engr., C. P. R. R.

F. D. LAKIN,
Div. Engr., Erie R. R.



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C. E. WRIGHT,
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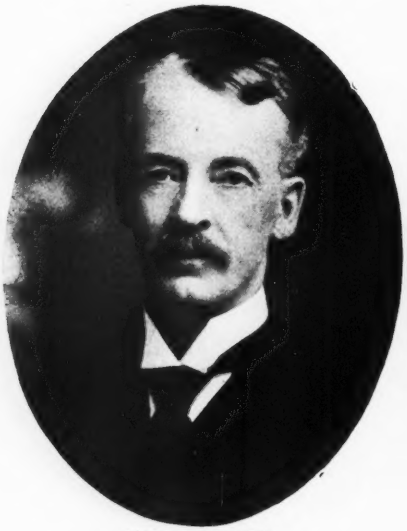
Div. Eng. M. W., Penn. Lines.

W. L. MORSE,
Term. Engr., N. Y. C. & H. R. R. R.

R. J. AREY,
Div. Engr., A. T. & S. F. Ry.

PHILIP PETRI,
Div. Engr., B. & O. R. R.



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Div. Engr., C. M. & St. P. Ry.

FRANK STUART HUNT,
Div. Engr., N. Y. C. & H. R. R. R.

E. J. BOLAND,
Asst. Div. Engr., Union Pacific R. R.

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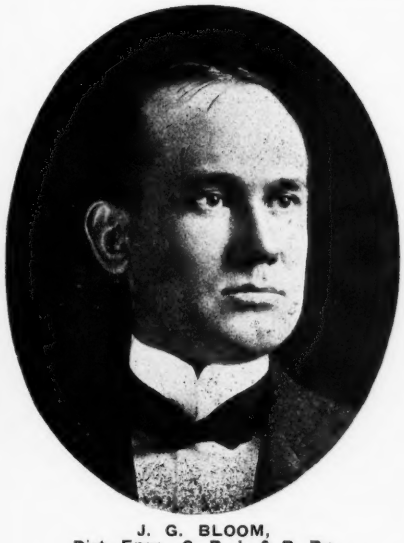
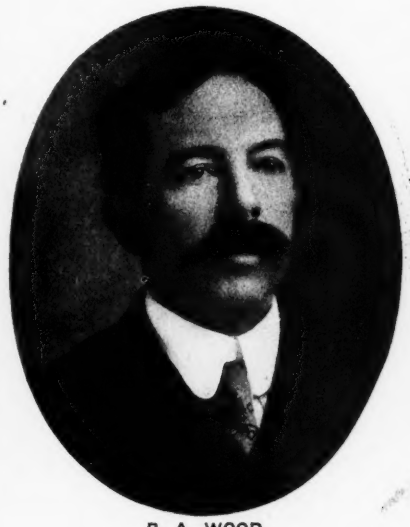


J. G. BLOOM,
Dist. Engr., C. R. I. & P. Ry.

F. H. BAINBRIDGE,
Res. Engr., C. & N. W. Ry.

J. S. BROWNE,
Div. Engr., N. Y., N. H. & H. R. R.



B. A. WOOD,
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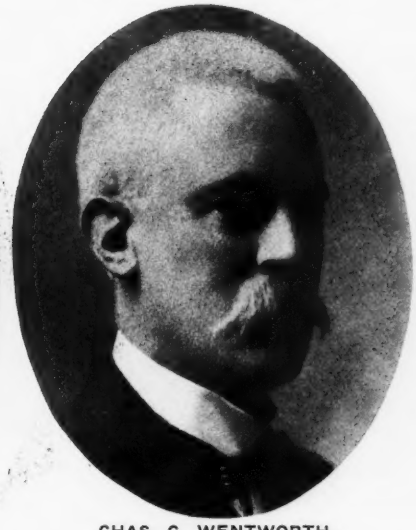
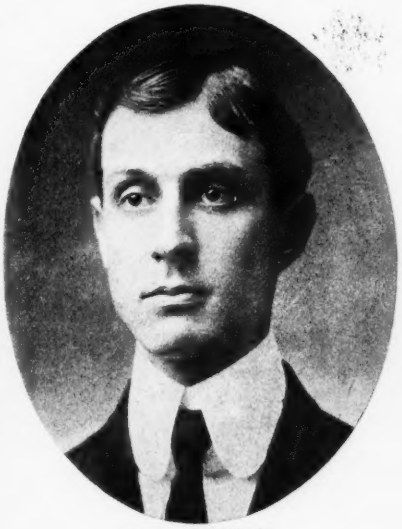
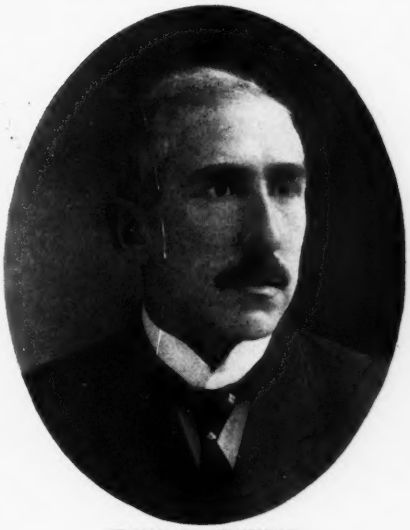


CHAS. C. WENTWORTH,
Prin. Asst. Engr., N. & W. Ry.

C. McC. LEMLEY,
Asst. Engr., B. & O. R. R.



H. R. ARTMAN,
Asst. Engr., Sea. A. L. Ry.



JENKS B. JENKINS,
Asst. Engr., B. & O. R. R.

J. A. LAHMER,
Prin. Asst. Engr., K. C. So. Ry.

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CHAS. H. HITCHCOCK,
Asst. Engr., P. & R. Ry.

W. C. HARVEY,
Asst. Engr., C. G. W. R. R.

CHAS. S. BATES,
Asst. Engr., Can. Pac. Ry.

WILLIAM C. HART,
Asst. to Chf. Engr., B. & O. R. R.

J. S. HESTLE,
Asst. Engr., L. & N. R. R.

E. M. DURHAM, Jr.,
Prin. Asst. Engr., Southern Ry.

OWEN CRAWFORD,
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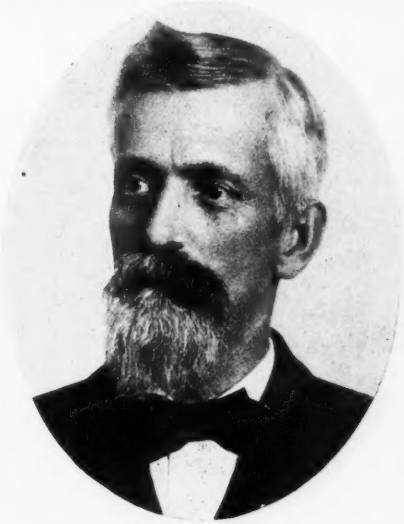
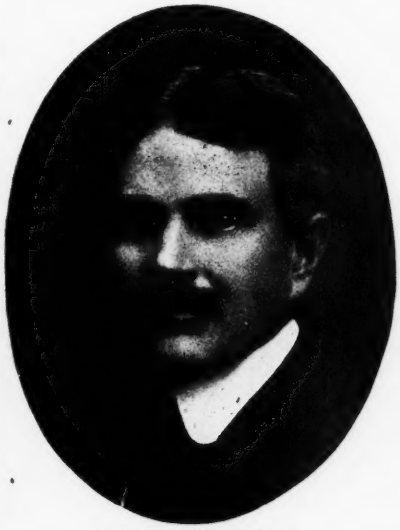
F. W. DENNISON,
Asst. Engr., Cent. Vt. Ry.



L. KINGMAN,
Asst. Chf. Engr., Nat. Rys. of Mex.

W. F. STROUSE,
Asst. Engr., B. & O. R. R.



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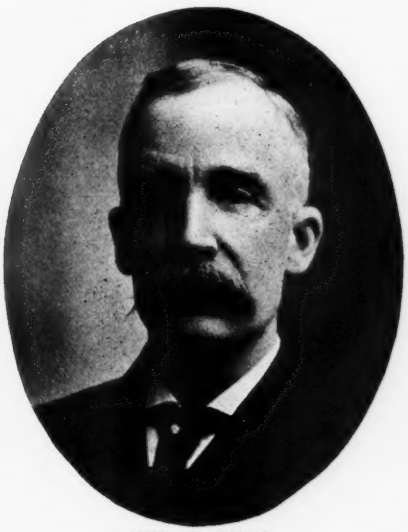

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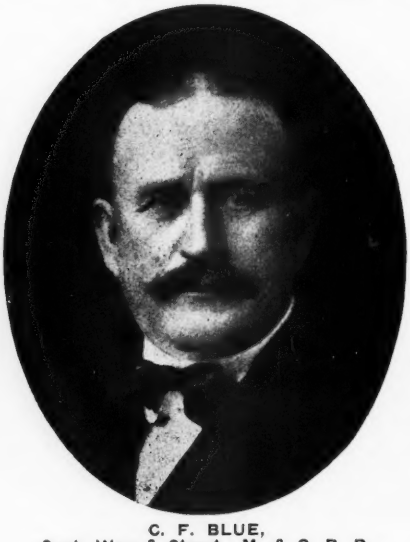

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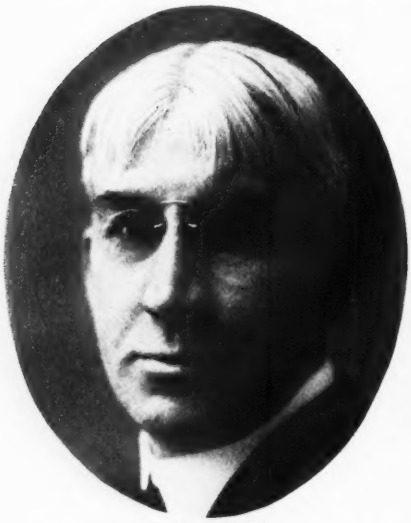

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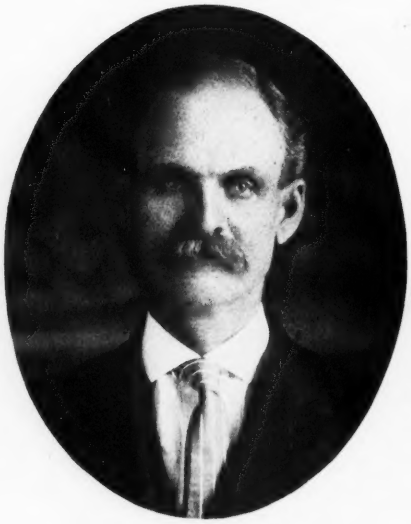

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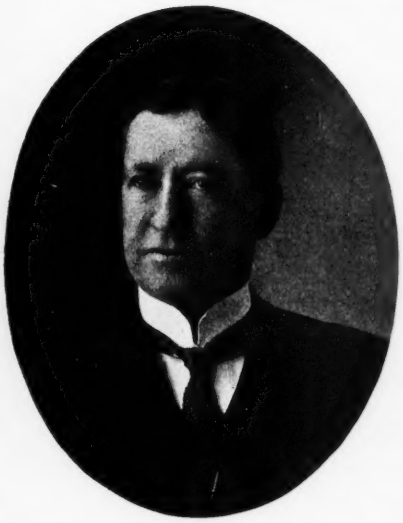

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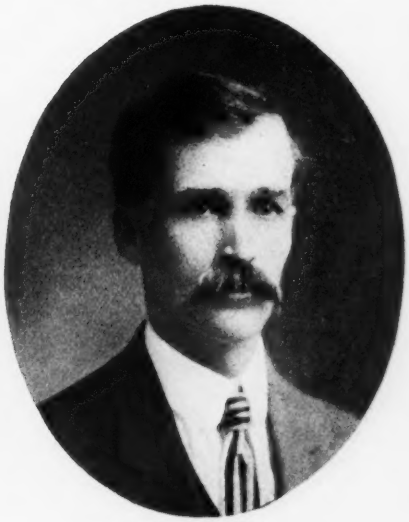

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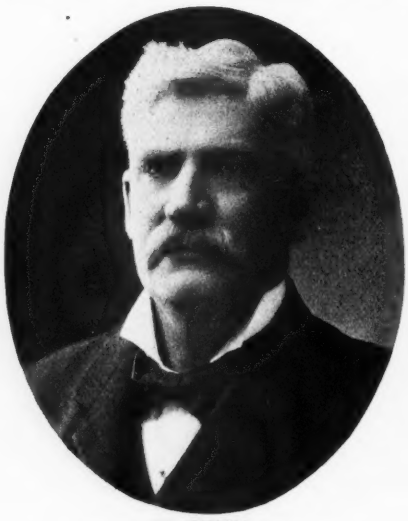

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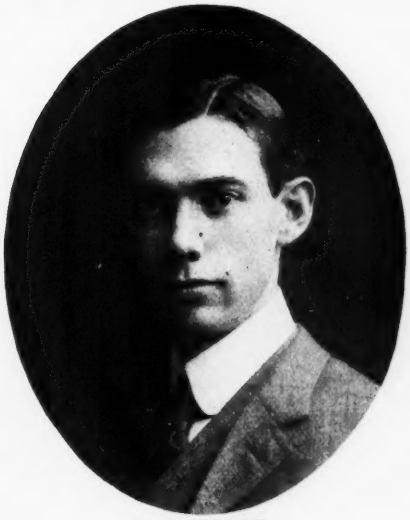

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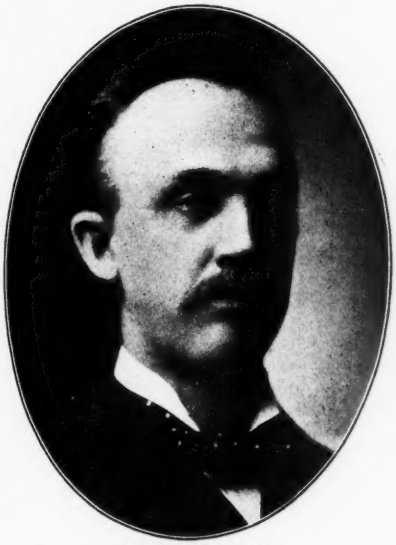

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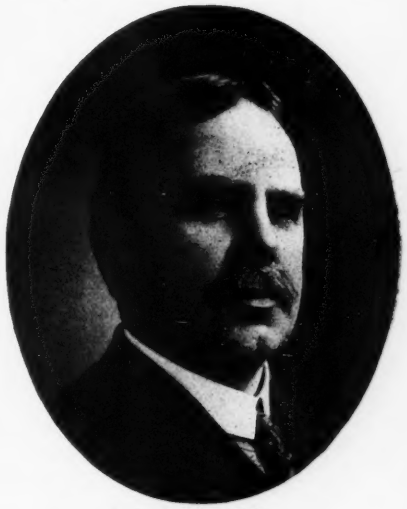

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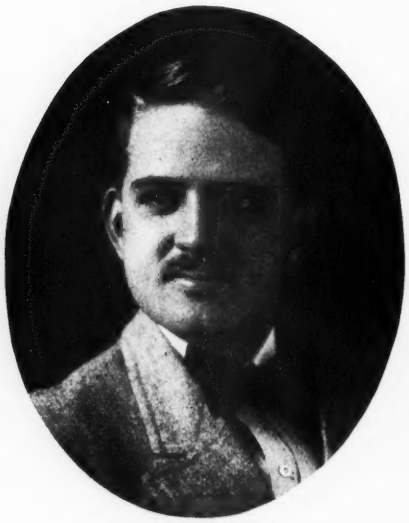

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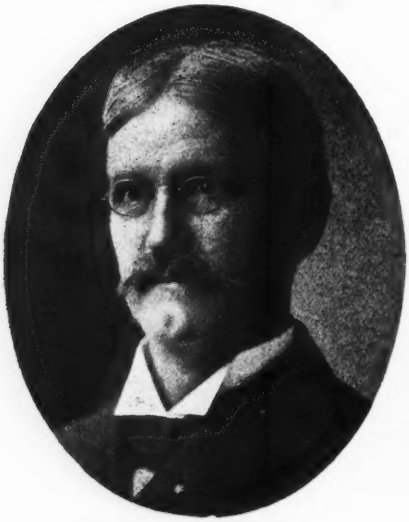

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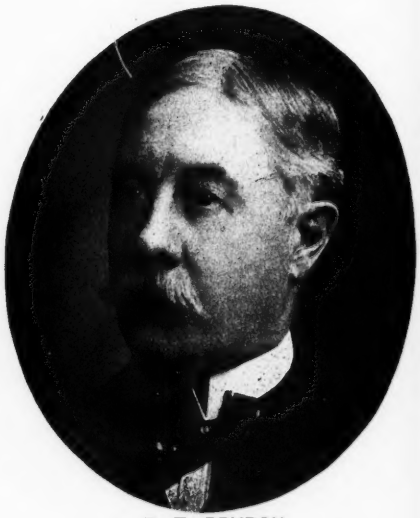

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RAILWAY ENGINEERING AND MAINTENANCE OF WAY.

March, 1910

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Tunnels, Particularly Subaqueous*

BY MR. R. B. WOODWORTH, M. AM. SOC. C. E.

A tunnel is a more or less horizontal underground passage constructed without the removal of the top soil. This definition, adapted from Sir Benjamin Baker's in the ninth edition of the Encyclopedia Britannica, excludes a few classes of construction commonly discussed as tunnels in the technical press. Under this definition a subway constructed by the cut and cover method is not a tunnel for the reason that while mining methods may be employed in the lower levels of the excavation, the structure is simply an open cut roofed over, either before or after the completion of the final excavation, and the operations incident to its construction have to do rather more with the proper support of adjacent buildings than with mining. Tunneling is essentially a mining operation and, therefore, the methods which are used in coal and metal mining, in shaft sinking, etc., are in genral the methods which apply in tunneling through rock and soft material. The construction and maintenance of our large railway systems have contributed not a little to the development of tunnel practice. This development has, however, always gone hand in hand with coal and metal mining and the progress in one has been facilitated by experience gained in the other.

HISTORY—Nature is the great tunnel builder and caverns in limestone rock everywhere testify to her persistence and success. The Luray Caverns of Virginia and the Mammoth Cave of Kentucky have been chiseled out of solid limestone by the action of water in following joints, fissures, cleavage planes, etc., dissolving the rock by mechanical and chemical action and transporting it to enrich and fertilize farms hundreds of miles away. By this action streams of water are collected within vast underground drainage basins and gush from beneath mountains in might rivers; other rivers disappear under mountains to reappear again through tunnels as roaring torrents. The Sinks region in West Virginia is filled with instances of this character.

Man is an imitator of nature, and can well profit by nature's experience, because she has been longer engaged at this work and has had wider experience than any of her creatures. He, threfore, follows nature in planning his work along the lines of least resistance, in attacking rock work along the joints, cleavage planes and other lines of easy fracture and in assisting mechanical processes by the use of applied chemistry.

Man's first tunneling operations were in direct imitation of nature, as the headings which he drove and the underground chambers which he constructed were intended for purposes of self-preservation. Along the shores of the Swiss lakes he drove piles and planted his frail dwellings thereon; in France and England primitive man dwelt in caverns; in later days he constructed underground passages and chambers for his tombs and the abode of his gods, such as are seen in the rock temples of Nubia, India, etc. The first duty of the king of Egypt on his accession was to construct an underground dwelling for his sarcophagus, and mining methods had reached with them a high state of development long before Romulus founded his famous city. Catacombs were constructed in the Crimea, in Asia Minor, in Syria, Alexander and Malta, in Syracuse, in Sicily, Chiust and Naples in Italy, and most widely and largely at Rome where the granular tufa forms a most admirable material for this purpose. They were first used for tombs, and during the persecutions, which began with Diocletian and extended down to the days of Constantine, preserved the lives of the Christians of Italy and the civilization for which they stood.

Man's ever-present need for water appears also in primitive tunnel construction. In the days of Assyria's supremacy a brick-arched tunnel was constructed under the Euphrates River 12 feet high and 15 feet wide by the method of stream diversion. This is probably the most early example of subfluvial tunnel construction. The chronicler of ancient Hebrew history in his discussion of the deeds of Hezekiah has not forgotten to mention his great claim on posterity in the building of a tunnel to carry the waters of Gihon from without the city walls to the Pool of Siloam. This tunnel was 1,707 feet long, driven by headings from each end, which met 944 feet from the Siloam entrance; and what is probably the oldest Hebrew inscription in the contemporary record inscribed by the masons 25 feet from the entrance which tells us that "On the day of the piercing through the miners smote each so as to meet his fellow—pick against pick," an indication not only of tunneling methods but of experience in engineering works of which today many of us are not aware. In Seleucia, not far from a natural tunnel, a river flows through a tunnel 20 feet wide and 23 feet high, cut 1,600 years ago through rock so hard that the chisel marks are still plainly visible.

The Romans were great tunnel builders and wherever their famous transportation lines extended throughout the length and breadth of the empire the well-constructed roads were marked by sewer works, excellent drainage and rock tunnels, while their famous aqueducts speak of wide experience in engineering. Pliny tells us of a drainage tunnel to Lake Fucino which was the greatest public work of his time, passing 3½ miles under Mt. Salviano. This tunnel was about 10 feet high and 6 feet wide and constructed from 40 shafts, some of which were 400 feet deep. Its building required the services of 30,000 men for 11 years, whereas in modern times with machine methods the same tunnel would have been constructed from headings run from both ends in 11 months.

The Middle Ages did not advance very far beyond the methods employed by the ancient Romans. The invention of gunpowder added somewhat to the facility with which tunnels might be constructed, but rapid improvement in tunnel methods and practice had to wait for the introduction of improved methods of transportation and above all specialized machinery. Modern tunnel practice dates from 1800, but has not yet reached its full development. We still need specialized boring and drilling machinery and applied uses of electricity for operation and transportation, and somewhat to the shame of our expert American

*Paper read before Railway Club of Pittsburgh.

miners it may be said that Europe holds the record for high tunnel performance.

CLASSIFICATION OF TUNNELS—A rational classification of tunnels is not a very simple matter. They might be classified in accordance with the purpose for which they are used into steam railway tunnels, subways, sewer tunnels, intake tunnels, drainage tunnels, mine headings, etc., but a classification on this basis would not be of any more value than if they were classified into straight, curved or crooked, or into large, medium and small. It being premised all the time that tunneling is essentially a mining operation, a rational classification appears to be rightly based on the classes of material through which they penetrate, as after all that is the essential feature in the method of attack and the character of the equipment required for their construction. These materials are rock, rock and earth and all earth, and these three classes may also be divided as to the presence or absence of water bearing strata. Where there are water bearing strata the use of compressed air may or may not be necessary, which would compel a further subdivision, making in all nine classes of operations, each calling for the solution of special problems.

Again, tunnels through water bearing strata are likewise subject to different conditions as to whether the water comes from the sides of the excavation or from above. In tunnels under streets and in many railroad operations the water may be confined to such as percolates through the sides where its pressure is comparatively light. Tunnels may be built under bodies of water, becoming subaqeous in deed and truth, and may penetrate through all rock, part rock and earth and all earth, and may be driven in such subaqueous conditions by the use of a shield with compressed air or without compressed air, also without a shield with compressed air and without compressed air. Problems of various kinds will arise conditioned on whether or not the rock covering is stable and thick or whether it is fissured, broken or thin. The material above the rock is also an element of some concern.

In the construction of an extensive railway terminal system it is possible that materials of all these kinds will be encountered and that all the various methods of construction might be called into play at some point of the operation, and indeed in a tunnel through a hill the excavation might pass from earth through earth and rock to solid rock. In this condition, however, the ordinary practice is to excavate the approaches to the tunnel by the open cut method and to use mining methods only after the portals have been passed. For the purposes of this paper, however, a rational classification of tunnels will be into rock, soft ground and subaqueous in accordance with the following detailed definitions:

1.—ROCK TUNNEL.—A more or less horizontal underground passage driven through stable material by the ordinary mining methods of drilling and blasting with or without timbering or lining, where such water as may penetrate through the material can be taken care of by within tunnel drainage.

2.—SOFT GROUND TUNNEL.—A more or less horizontal underground passage driven through yielding material by ordinary mining methods of excavation with or without a shield and at normal or low air pressures, water percolation under gravity head being disposed of by within tunnel drainage.

3.—SUBAQUEOUS TUNNEL.—A more or less horizontal underground passage driven under a body of water through yielding material by ordinary mining methods of excavation with or without a shield at high air pressures against hydrostatic head, ingress of water being prevented more or less absolutely.

These definitions are based on the distinction between mining methods of blasting and excavation and ordinary open cut methods and, therefore, treat the whole system of tunneling as a branch of the art of mining. They are strictly in line with the definition adopted for a tunnel at the outset. If, however, it is maintained that a subway excavated under city streets or elsewhere by the open cut and cover method is to be looked upon from the standpoint of the completed work as distinguished from the methods involved in its construction, then we may have a fourth class of tunnels, viz.:

4.—OPEN CUT TUNNEL.—A more or less horizontal underground passage driven through hard or soft materials by ordinary methods of excavation and covered by a flat or curved roof after the excavation is completed.

It is apparent that a tunnel shaft may be driven through soft or hard materials with or without lining by mining methods, but an essential feature of the designation tunnel is its more or less horizontal character.

ROCK TUNNELS.—The rock tunnel is the simplest application of the methods of mining to the construction of underground passages and modern advances have been due not to any radical change in the methods of attack but to the introduction of high explosives, power drills driven by steam or compressed air and modern methods of transportation with electricity or compressed air.

METHODS OF ATTACK.—Mining methods reflect to a large degree national characteristics. In England mine shafts are usually circular; in the United States almost always retangular; in England long wall methods are common; in the United States almost unknown. These differences are due in part to natural conditions and in part to diverse experience and more or less familiarity with machine methods; consequently the differences which exist in the art of mining exist also in the branch of tunneling. Fig. 1 shows a typical design of a single track railroad tunnel driven through rock and lined with brick supported on concrete walls. It is subdivided into sections lettered to correspond with various methods in which material is removed. Tunnel excavation usually begins by the driving of a heading either at the top or bottom of the excavation.

In the Austrian drift method of excavation the heading is driven at the bottom of the tunnel through section A, track laid for mine cars and advanced some distance ahead of the full section excavation. This advance heading is followed by the removal of sections B, C, D and E in their respective order, and if invert is to be made below the general level of the tunnel, it is completed as a final excavation.

The German method is to begin with the top heading through section B and to follow with C and D, completing the excavation down to a level and leaving a bench extending the entire width of the tunnel. This bench is then next attacked by two side headings in the bottom through E, leaving a firm central pillar A to be removed at the completion of the cross section excavation, but permitting mine cars to be run on each side thereof for prompt removal of material.

In soft ground the German method is to drive side headings at the bottom of E, which are usually subdivided into three parts and removed in successive layers by caving into the cars below. After both lower side sections E have been removed, a top heading is driven through B to be followed in turn by the excavation of C and D. During the progress of this excavation the lining of the tunnel is put in and the timbering erected thereon, leaving the solid central pillar A to be removed, as in the German method of rock excavation.

The English system is to drive a top heading in B from which sections C are excavated and crown bar timbering placed. A heading is then driven in the bottom of A and excavation proceeds, as in the Austrian or drift method, by the removal of the lower part of D sections as a bench and the excavation of top of A and the side sections E.

The Belgium method is to drive a top heading likewise and to excavate side sections C and D down to the level, timber-

ing by the crown bar method as in English practice. The central section A is then removed to be followed in turn by the lower side sections E.

The American method, if any exclusive system may be designated by that name, has ordinarily been to divide the tunnel into three transverse benches and to remove them in order from the top down by taking out, viz., the side sections C, the top of B, the lower portion of B, the side sections D and the lower sections A and E; thus in a measure applying to tunnel work methods which are more common in open cut excavation.

The indications are that the most economical method of tunnel construction is the Austrian or drift method which drives a bottom heading first and permits the construction and maintenance of a transportation system in proper position for constant use without the necessity of track removal. A miner also in mining coal in successive levels works always to the heading below, shoveling his material downhill wherever possible.

DRIVING RECORDS.—The interest in speed records in rock tunneling is due to the fact that the time needed to complete the entire tunnel, and consequently the period during which vested capital lies idle, is wholly dependent on the speed with which two small headings can be put forward; only a small party of men can work in each heading and concentration of working forces is not possible; therefore, engineering construction looks upon speed of work in tunnel driving as an item of supreme importance. High efficiency of tools and methods and careful attention to the prevention of delays of whatever character are the main features in the determination of tunnel progress. Natural conditions may, of course, affect the work, such as unfavorable direction of strata fissured rock, presence of water, etc. Where the rock is firm, solid and dry, one month's work may be double the ordinary rate of advance. The record for high tunnel driving is now held by the Alpine tunnels, such as the Simplon, the Arlberg and the Loetschberg. The greater length of these tunnels and the possibility of installing a more perfect plant and a more thorough organization may account in some measure for the comparative supremacy over English and American records. A few of these may be worth our attention, it being remembered all the time that the kind of rock, its hardness and specific gravity, the presence of joints, seams, cleavage planes or other lines of structural weakness, and the size of the heading itself, are elements of large importance in any comparison.

The Joker Drainage Tunnel, Red Mountain, Col., 5,055 feet long, was driven 282 feet in its best month, July, 1904, through Andesite breccia. The heading was 12 feet by 11 feet timbered 8 feet 6 inches by 7 feet. Drilling was done with water Leyner drills and material was mucked by men in iron cars hauled by mules, though later transportation was effected by twelve electric locomotives.

The drainage tunnel at the Iron Mountain Mine, Superior, Mont., 5,853 feet long, was driven in 7 feet by 6 feet heading through quartzite 288 feet in one month, January, 1907. Average rate for the entire tunnel 233 feet per month. Cost per foot, $14.50.

The 6 feet by 9 feet heading of the Newhouse Drainage Tunnel, Idaho Springs, Colo., 22,000 feet long, was driven 290 feet in May, 1906, through granite and gneiss.

The best progress made in the construction of the Roosevelt Drainage Tunnel at Cripple Creek Colo., 15,550 feet long, was 435 feet in January, 1909. Average monthly advance for twelve months 292 feet. The heading 10 feet wide by 6 feet high with a 3x6-foot drainage ditch on one side of the floor, was driven through Pikes Peak granite by water Leyner drills, No. 9, mounted on a horizontal cross bar wedged against the sides of the bore, two drills being operated in each heading. The muck was taken out in steel cars of 36 cubic feet capacity on a single track railway in trains of 10 to 12 cars hauled by mules.

The Gunnison Tunnel, an essential part of the Uncompahgre Valley reclamation project, is the longest irrigation tunnel in the world. It is 30,582 feet in length and the headings were driven to a meeting point on July 6, 1909, as the culmination of 54 months' continuous work. The best record made was the driving of an 8x12-foot heading 842 feet in one month in soft shale. The best record in granite for any single month for one heading was 449 feet, January, 1908. In the hard granites the Sullivan 3-inch piston drill was used; in less refractory ground Sullivan 2½-inch drill; in the shales the Jeffrey coal augur, air driven, was used with highly satisfactory results; the Leyner drill was also used in certain classes of the work. The record headings were driven by the under-cut method.

The Elizabeth Tunnel of the Los Angeles Water Works,, California, 26,860 feet long, was driven 466 feet in granite in October, 1908. The heading 12x12 feet was driven with a model 6-A water Leyner drill, the mucking being done by hand and the tramming by electric motors. Cost per foot, $31.81.

An excellent record in driving a railroad tunnel was made in 1908 on the Bitter Root Tunnel of the Chicago, Milwaukee & St. Paul Railroad, through the Bitter Root Mountains, Montana. The tunnel was driven by the regular top heading method and was advanced 563.5 feet in May of 1908, the average advance for the three months of March, April and May being 499.7 feet. The rock is a quartzite somewhat laminated and the heading is the full roof arched section for a double track tunnel.

The new Croton Cqueduct has a length of 30.87 miles, of which 29.63 miles is in tunnel, being horseshoe in form, 13.53 feet high and 13.6 feet wide and carrying an estimated capacity of 318,000,000 gallons of water per day. This is the longest tunnel in the world. It was driven from shafts about a mile and a quarter apart along the length of the line, and the best record in any one heading was 550 feet per month. This was in hard rock in an unusually large heading and the ordinary progress was about 175 feet per month.

Fig. 2 shows the method of attack and the sequence of operation in driving the south heading of the Loetschberg Tunnel, which is being built in Switzerland on the line of the railway to connect Berne with the Simplon Tunnel route to Italy. This tunnel when completed will be about 8½ miles long. The bottom heading, 6 feet 6 inches high by 10 feet wide, is driven by machine drills mounted on drill carriages, and the rock encountered varies from granite to gneiss and is hard drilling. Compressed air is furnished by two electrically driven Ingersoll Rand compressors of the cross compound two stake type. The record in this tunnel is 574 feet in September, 1907. Average speed for five months, 555 feet per month.

A record of 579 feet during the month of May, 1909, has been made in the Fernando Tunnel, located about 25 miles north of Los Angeles and driven in connection with the construction

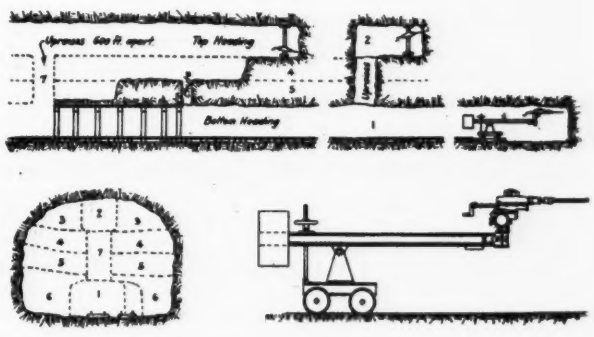

Fig. 2—Loetschberg Tunnel Methods.

of the Los Angeles intake through soft sandstone. The tunnel has a section of 10 feet 8 inches by 11 feet 2 inches, and the whole section is carried forward in one operation by three shifts of sixteen men each. The completed tunnel will be 9,112 feet long.

The Arlberg Tunnel, in the Alps, 33,696 feet long, was advanced through schist and gneiss 641 feet in July, 1883, by the use of Brandt rotary drills. The average speed of driving for 40 months was over 400 feet per month.

The world's record for rapid tunnel driving is held by the Simplon Tunnel, 64,818 feet in length, in the construction of which a heading 6 feet 6 inches by 9 feet 8 inches was driven through schist and gneiss 755 feet. This figure was made in July, 1904, in the south heading, the best speed in the north heading being made in December, 1902, at the rate of 682.2 feet. In both headings the work was interrupted and delayed by bad rock, the average rate of speed of 426 feet per month for 76 months being exceedingly good.

If now we compare these records with that of the Hoosac Tunnel, 4 2-3 miles long, driven in 1865-1873, it will be noted at once how great the improvements have been in tunnel methods. The best record of the Hoosac Tunnel was 184 feet per month with machine drilling. It will also be noted how far short we come of the best European records, the secret of which appears to be that a very careful study has been made of the various causes of delay in the successive processes of drilling, blasting, mucking out and setting up the drills again, with the result that a radically different method of mounting the drills in the heading has been employed and also a different system of blasting used from that practiced in the United States.

Fig. 2 shows that the bottom heading in the Loetschberg Tunnel, on which the speed of the tunnel depends, is driven by a machine drill mounted on its own separate drill carriage, which permits the speediest possible removal for blasting and renewal of work after blasting is over. This bottom heading is supplemented by the regular pneumatic drills in the other headings which blast material down into the bottom for speedy removal. Excavators have been invented and used to some extent in the United States. The Jackson Tunneling Machine, described in Engineering News for February 22, 1908, is intended rather for use in clay. The Mersey Tunnel, however, was bored in part with a Beaumont Machine cutting to a diameter of 7 feet 6 inches, and doubtless we have not yet come to the full development possible in the way of multiple drills and drilling machines.

LINING.—However stable the rock may be, very few tunnels are now allowed to stand without some form of lining, as the best rock is liable to swell and to fall, making track maintenance more difficult. In the olden days timber lining was common and has not yet entirely gone out of fashion in such sections as there is still a supply of good timber close at hand. The Bitter Root Tunnel of the Chicago, Milwaukee & St. Paul Railroad is lined with timber made up of 12 inches by 12 inches longitudinal sills and wall plates with 16-foot posts and a five-segment arched rib spaced according to the character of the material to be supported, usually 3 to 4 feet center to center, but in many cases the material necessitated putting the timber closer together. Two-inch lagging is used on the side of the tunnel and 4-inch on the arch.

There is always in a timber lined tunnel danger of fire from locomotives, and the same considerations which seem to forbid the presence of timber in mine shafts apply as well to its use as a permanent tunnel lining material, consequently it has been to a large extent superseded by brick. The Mt. Washington Tunnel, of the Pittsburg Railways Company, is a very good example of a two-track brick lined tunnel driven through stable material. Water Works tunnels are to a large extent lined with brick, a most noteworthy example of which is the land tunnel for the new water works, Cincinnati, Ohio, constructed in 1903. This tunnel is 22,264 feet long and carries treated water from the shaft at the clear water reservoir to that of the city pumping station. It is 7 feet in diameter in the clear and 9 feet 6 inches over all, and is lined with two rings of specially made radial pressed vitrified shale brick laid with close joints and backed with concrete, the minimum thickness of the concrete being 6 inches. Where the tunnel passes beneath the Little Miami River the lining is reinforced by rings of ¾-inch round steel bars 2 feet center to center. The tunnel was driven through limestone and shale rock and the few streams of water encountered were taken care of by driving pipes into the seams so as to discharge the water within the tunnel.

The Raton Hill Tunnel, of the Atchison, Topeka & Santa Fe Railroad, at Raton Pass, on the Colorado State line, built in 1908, 2,790 feet in length, is lined with reinforced concrete varying in thickness from 2½ feet at the base to 2 feet at the springing line of the arch. The arch ring also has a thickness of 2 feet. These dimensions apply to soft ground. In loose rock the thickness is 2 feet at the base, 18 inches at the spring line and 18 inches in the arch ring. Irregularities between the excavation and the outside limits of the concrete were filled with loose stone packing laid by hand.

The Bergen Hill Tunnel, of the Lackawanna Railroad, is likewise lined with concrete and the rails of the double track are carried on concrete laid on the rock bottom of the tunnel. The concrete tunnel lining is two feet in thickness.

The Gunnison Tunnel is a timber lined tunnel with a concrete facing, but differs quite a good deal from ordinary railroad tunnels in the fact that the tunnel itself is intended as an aqueduct and the tunnel lining forms a flume for the passage of the water. This flume is built in the ordinary manner with timber sets three feet center to center, lagged with planking and wedged tightly against the excavation by cord wood. The whole wooden structure is filled within with concrete to the finished dimensions, thus providing a structure of maximum resistance to stress and of a waterproof character.

The tunnel profile shown in Fig. 1 is drawn after that of the Langsville Tunnel of the Kanawha & Michigan Railroad, and the permanent lining consists of a reinformed concrete wall eight feet high on each side, with brick masonry above and with brick arch. The reinforcement of the side walls consists of old rails and truss rods from old cars. The rails were set in holes drilled in the bottom of the tunnel and built into the brick walls above, thoroughly tying the brick work, concrete and tunnel floor together. After the reinforcement and forms were in place the concrete was mixed in a Smith mixer run by compressed air and mounted on an ordinary flat car, and was dumped from the car directly into the forms of the walls. The bricks were laid with Portland cement mortar with as thin joints as possible, the harder burned bricks being selected for the exposed courses.

The Duluth Tunnel, of the Wisconsin Central Railroad, is lined with an arch and side walls of concrete, which is mixed in the proportions of one part Universal Portland cement, three parts bank sand and five parts gravel, mixed in a one-yard Smith mixer. Flat cars were operated from a narrow gauge track laid on the cross braces between the wall plates and the tunnel timber. A short piece of track was laid on the deck of each of these cars to carry a small hopper car in which the concrete was transported, which permitted the delivery of the concrete directly to the top of the wall forms. The concrete for the arch was shoveled into place from the cars.

The concrete used in the lining of these tunnels was put in place by the use of ordinary removable wooden forms. Modern methods for the mixing and placing of concrete by the use of removable steel forms are to be seen in the Blue Island Avenue Tunnel, City of Chicago, constructed under the supervision of Mr. George W. Jackson, president and civil engineer of George W. Jackson Company, Inc. The Jackson lagging ribs are built of 5-inch 9-lb. channels bent to the radius of the circle required to bring the lagging to the proper curve, with the flanges of the channels out. Each rib is made of four sections, each section

being a 90-degree arch of a circle, the inside diameter of the tunnel being 8 feet. The lagging used with these ribs consists of 3-foot lengths of ¼ inch plates 12 inches wide. These plates have a light steel angle riveted along both sides and both ends so as to form a rim entirely around the plate flush with the edges of the latter. The angles on the sides of the plates are notched to fit over the flanges of the channels of the ribs, which can thus be spaced accurately by placing a few of the lagging sections. At the same time the joints between the edges of the adjacent sections of lagging can be made quite smooth and tight enough to hold concrete. As fast as the mining is carried ahead of the finished tunnel lining, the concrete in the lowest part of the invert is generally placed to provide for the erection of the steel lagging ribs. When the ribs are placed, the lagging for the lower part of the circle is set and the invert lining finished up part way on each side. The spoil-car track and shoveling platforms can then be laid on cross ties formed for a horizontal angle attached to each lagging rib, and the concrete lining can be completed at leisure. After the concrete is set the removal of the form is very readily accomplished by simply loosening the bolts at the top and side joints of the lagging ribs and by knocking out the wedges. The forms are then carried ahead and re-erected, only a sufficient amount of steel ribs for lagging being provided in each heading to permit the concrete to set the required time. That these forms are practically indestructible under service is indicated by the fact that upward of a half-mile of concrete tunnel lining has been placed with each set of them in use.

The same method of removable steel forms has also been used in the construction of the Southwest Water Tunnel in Chicago, likewise built by George W. Jackson Company, Inc. While the Blue Island Tunnel was 8 feet inside diameter, the Southwest Water Tunnel is horseshoe shape in cross section of variable dimensions equivalent at different points to 12, 14 and 16-foot circles. In this instance the lagging ribs were 6-inch channels. This form of interlocking steel ribs, or some similar method of construction, will doubtless reduce very materially the cost of concrete lining; so also will doubtless the use of the Telescopic Collapsible Steel Form and Traveler, manufactured by the Ransome Concrete Machinery Company, and described in the October 2, 1909, issue of the Engineering Record.

Reinforced concrete commends itself for rock tunnel lining. Whether or not it will eventually replace brick for such purposes will depend on its performance in recent installations. What form the reinforcement will take will depend largely on circumstances, but the reinforcement should always be designed to increase materially the strength of the concrete and be in such form as to perform the most service for the least weight. In the construction of the Aspen Tunnel, of the Union Pacific Railroad, in Wyoming, unexpected difficulties were encountered. A double track tunnel was driven by the ordinary American method of taking out and timbering the top third of the excavation and the benches were removed by the use of the steam shovel. The material through which the tunnel penetrated was exceedingly unstable, being a disintegrated soft shale rock. Here slips were frequent and heavy timbering was used to overcome the tendency of the whole mountain to slide into the excavation. When heavy timbers proved too light, 12-inch 31.5-lb. beams bent to the curve of the tunnel and erected in three sections spliced together were tried. These also proved too light for the work and many of them were seriously bent and twisted under the tremendous earth pressure. The settlement was finally stopped and the tunnel completed by the use of 12-inch 55-lb. I-beam rings spaced two feet center to center and filled in solid by concrete. Inasmuch as steel mine timbers, in more or less similar form, have been found highly satisfactory in coal mining operations in this country and abroad, these seems to be no reason whatever to prevent their similar use in standard railroad tunnel construction where heavy loads are to be sustained and where the ordinary methods of timbering appear likely to prove inadequate.

SOFT GROUND TUNNELS.—The essential differences between a rock tunnel and a soft ground tunnel is that the former is drilled and blasted while the latter is bored and dug; machine drills give place to augers, and timbering common in stable ground is replaced by the fore-poling method of construction. If the ground contains no water and danger of subsidence is small, the timbering necessary is reducible practically to the amount required properly to support the excavation during the process of lining. If, however, the material contains water and the excavation is carried on at shallow depth in close proximity to buildings, the use of a shield may be found desirable, and so also may the use of compressed air at a low pressure, ordinarily ranging up to 8 or 9 pounds above normal.

The largest system of soft ground tunnels in the world is the network built by the Illinois Telephone & Telegraph Company below the streets of Chicago, which now extend 66 miles. These were first built for telephone and telegraph cable conduits and have been later extended to carry a narrow gauge transportation system for freight traffic. The tunnels, of a horseshoe form 6 feet wide and 7 feet 6 inches high inside demensions, are constructed of concrete 10 inches thick on the crown and sides and 13 inches at the bottom. The method of construction was as follows:

The bore was dug in the clay for a distance of 20 feet and about a foot larger all around than the completed tunnel. The 13-inch concrete bottom was then put in place and upon this were placed forms made of 5-inch channel bars in two pieces, curved to the exact size of the inside of the completed tunnel. Outside of these forms boards 20 feet long were placed, one at a time, on each side and the concrete rammed into the space between the boards and the clay. When the crown forming the key was reached boards 3 feet long were used. It was afterward found better to build 15-foot sections instead of 20 feet. The concrete was composed of one part Portland cement, three parts sand and five parts gravel.

The tunnels were commenced in September, 1901, and were driven in stiff blue clay containing very little water, but occasional pockets of gas and quicksand were encountered. As a precaution the work was all done on the pneumatic system, the air pressure being about nine pounds per square inch. The material was excavated with spades and drawknives and hauled away in small cars 20 by 48 inches inside measurement. The main tunnels are built to a depth of about 20 feet from the street surface to the crown tunnel. As they are located under the center line of the street, they are clear of the lines of pressure from the buildings and are subject only to the pressure due to the overlying material. The work, therefore, is delicate in its nature, but with the low air pressure there has been practically no trouble from settlement of the ground; where driven without air small subsidence has sometimes occurred.

The intake tunnel of the Municipal Water Works of Gary, Ind., built 1908-09, is likewise an example of the soft ground tunnel driven without shields. This tunnel has a horseshoe-shaped cross section equivalent to a 6-foot circle and a total length of approximately 15,000 feet. It is being driven through the thick stratum of clay underlying Lake Michigan and at a depth of about 20 to 30 feet above bed rock. A section of tunnel about 225 feet long was first driven from the bottom of the pump shaft and lined without the use of compressed air in the heading. An air lock was then installed at this point and since then all the operations in the heading have been handled under air pressure. The work in the heading is prosecuted by three 8-hour shifts of laborers. The mining is done by two shifts, which advance the heading 24 to 27 feet under normal conditions, and the concrete lining for the bore of the tunnel is placed by the third shift, so that 24 to 27 feet of lined tunnel are completed every 24 hours. The most of the clay removed is of such a nature that it can be cut with a draw-knife, although sharp spades and adzes

are occasionally used. The excavation is not timbered as it progresses since an air pressure of 12 to 16 pounds is sufficient to maintain the shape of the bore until the concrete lining can be placed. The forms for the concrete lining consist of pieces of 3-inch wooden lagging 3 feet long, which are held in place by tee iron ribs bent to the horseshoe shape of the tunnel cross section. These ribs are spaced 3 feet apart on centers and are made in three pieces to permit of ready removal.

The Baltimore Belt Tunnel, Baltimore, Md., 1.4 miles long, is a double track tunnel through sand and clay, built by the crown bar method of timbering in 1890-1893, and is notable on account of an attempt to carry forward the excavation by means of a roof shield running on side walls constructed previously.

The construction of tunnels by this half shield method proved successful in 1896 on a portion of the Boston Subway under Tremont street and the system has had rather wide application. The shield weighed about 22 tons and was calculated to sustain an approximate load of 640,000 pounds; was 29 feet 4 inches wide over all, with a rise of 4 feet 4 5-16 inches and was composed of two plate girders 3 feet 8 inches and 4 feet apart, with cover plates extending 4-0 inches beyond the girder, while an additional top plate extended 2 feet in the rear. Under each foot of each girder was an iron casting which fitted into a recess in the cast steel shoe. These shoes rested upon two lines of 10-inch steel I-beams imbedded in the concrete side walls forming the track upon which the roof shield slid as it was pushed along. The shield was propelled by ten 6-inch hydraulic jacks located around its upper portion. The outer ends of the plungers were fitted with collars which abutted upon 2¼-inch cast iron round bars built into the brickwork of the arch and forming continuous lines of metal to resist the thrust of the jacks. This device was apparently first used by Mr. Walter I. Aims in the East River gas tunnel at New York City. As soon as the shield had been pushed forward about 3 feet the timber centering was erected behind it and the brick arch lining of the tunnel built. During this time a heading 6 feet high and the whole width of the tunnel was excavated ahead of the shield and supported by posts and poling boards, which were removed as the shield reached them. The material was mainly gravel and stiff clay. The depth of earth above the tunnel varied from 6 feet 9 inches to 13 feet and a progress of about 50 feet per week was made. The two side walls were built in advance headings. The arch was built by means of the shield and the center core of material removed later.

The half shield method has also been employed in 1908 in the construction of the intake tunnel of the Lawrence Avenue Pumping Station, Chicago, Ill., 1,446 feet long. This tunnel is used in connection with the intercepting sewerage system of Chicago for furnishing water from Lake Michigan for dilution of the sewage and is believed to have the largest cross section of any that has been built for similar purposes. It has a full center arch with a span of 20½ feet with a rise of 8 feet 11 inches. The bottom is an inverted flat arch so that the total height of the structure at the center line is 14 feet. The cross sectional area is slightly more than equivalent to a 16-foot circle.

The cover between the crown of the arch and the bottom of the lake varies from 18 feet at the outer end of the tunnel, where it is made up of 4 feet of sand at the top and the remainder clay, to 34 feet at the shore shaft. The upper part of the bed of clay is of a soft blue character which increases in stiffness with the depth, so that the invert and the bench walls of the arch of the tunnel are founded on hardpan. Owing to the large area of cross section it was considered impracticable to make the whole bore at one operation. The plan was, therefore, adopted of driving two headings, each 7 feet high, 6 feet wide at the top and 9 feet wide at the base, for the bench walls of the arch and of building these walls in advance of the removal of the core of the excavation and the completion of the balance of the tunnel. The drifts were excavated by hand with draw-knives, adzes and similar tolls without air pressure, though they had to be lined closely with bents of 8x10-inch timbers.

The shield used in driving the main tunnel excavation was built up of steel plates and structural shapes and conformed in outline to the arch of the tunnel. It traveled on rails laid on the bench walls of the arch built of concrete in the advance headings. The shield was five feet long with a projecting cutting edge around its rim at the front end and was braced apart at the bottom by a horizontal steel platform carried by five 10-inch 40-lb. I-beams. A heavy plate on the bottom of each side of the shell of the shield rested directly on a pair of rails on timbers carried by the corresponding bench wall. The shield was advanced by means of twelve 6-inch hydraulic jacks equally distributed around the periphery of its shell. The work was carried on under an air pressure of 8 pounds as an insurance against difficulty and the regular sequence of operation was as follows:

First the concrete bench walls were built ahead 150 to 200 feet in the side headings. When the concrete had set the shield was timber lining of the excavation. This lining consisted of segments in 3 and 4-foot lengths cut from 7x10-inch oak timbers and pushed ahead with its own jacks which re-acter against the was placed immediately following the shield to retain the soft bulging clay through which the greater part of the tunnel is built. The brick arch was constructed in sections 22 feet long from a timber traveler of that length which operated on rollers on timber laid on the hardpan. After the arch work was built the excavating and concreting of the invert were completed.

The latest practice by French engineers in shield construction is shown in Fig. 3, which is a cross section of a tunnel with the shield in place used in the construction of the Metropolitan Railway, Paris. The roof of the Metropolitan Railway Tunnel is but little below the surface of the street and the tunnel is a double track structure with a clear span of 23.29 feet and with a rise of 6.79 feet in the arch. The arch abutments and floor are all of masonry. The first portion of this tunnel was constructel in 1898 with a half section shield on which the arch was built and the abutments constructed last, but the results were not satisfactory and the failure of the shield was largely due to the fact that the soil penetrated was not homogeneous. Then, too, in moving forward the shield carried with it around its outer surface a certain thickness of earth which caused undulations on the surface ground and by its broken condition threw too much weight on the tail end of the shield. There was thus a tendency in the shield to rise at the forward end, while the fresh arch masonry was damaged under the friction of the shield when it was moved forward.

The characteristics of the new roof shield designed by the engineers Radenac and Raguet to avoid these troubles were its length and the more stable support provided for the shield rollers when the shield moved forward. In actual use the shield has been advanced as much as 20 feet in 24 hours. The shield was made of an outer steel shell shaped with the extrados of the arch and its total length was 24 feet 6 inches. This shell was supported by four cross beams connected by 38 longitudinal girders, of which 20 extended forward to support the front end and 18 carried on rear end. The webs of the girders were stiffened with angle iron, making a beam box of each pair of girders. Ten of these box beams supported the rollers on which the shield was moved and nine of them carried the hydraulic jacks. The total weight of the shield and its framework was 34 tons. The steel cutters on the front of the hood were eight in number. The rollers were not operated on top of freshly laid masonry, but traveled on steel centers which were built of beams shaped to the arch and divided into two equal parts connected by bolts. The foot of this center extended about 18 inches below the

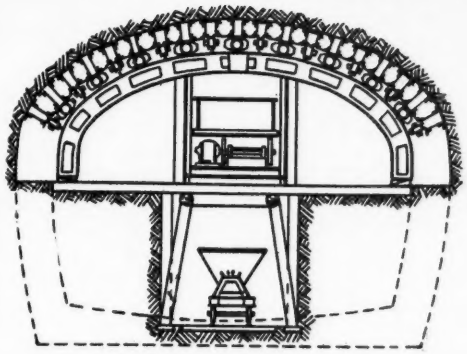

Fig. 3—Metropolitan Tunnel.

spring of the arch and rested upon a cross tie made of two steel plates and angles. This tie obviated the tendency in the center to spread and the whole center was carried on longitudinal sills supported by posts driven in the undisturbed ground of the lower advance gallery. The movement of the shield over these centers was very steady and the surface undulations did not exceed 3 inches. The hydraulic jacks were 8 feet 8 inches long and had a stroke of 3 feet 7 inches. They were fastened to the shell of the framework and their pistons acted upon thrust blocks set between the center ribs. As these ribs were theoretically immovable, the shield shell and its framework advanced. As the shield moved forward, sheets of thin steel replaced it to prevent the earth from falling in. These plates were held in place by temporary timbering until the masonry was completed, the plates remaining in the ground. The masonry was built on wooden lagging laid on the steel centers.

The most recent example of the half shield method of construction in soft soil is to be found in the construction of the Detroit River Tunnel, of the Michigan Central Railroad, now building. The total length of this tunnel is 12800 feet, made up of 1540 feet open cut, Detroit end, 2135 feet approach tunnel, Detroit end, 2625 feet subaqueous, 3100 feet approach tunnel, Canadian end, and 3400 feet open cut, Canadian end. The cross section of the approach tunnel on both sides of the river is practically the same, each consisting of two single track structures with a vertical wall 4 feet thick between. The roof of each half of these structures is a full center arch 2 feet thick on the American side and 2 feet 6 inches thick on the Canadian side with an inside radius of 8 feet 3 inches and a clear height of 18 feet above head of rail. Owing to the great extent of the excavation required it was realized that in the event it became necessary to handle the excavation by the shield method operating either in the open or under pneumatic pressure, a shield large enough to permit the twin tunnels to be built simultaneously would be impracticable. The decision was, therefore, made to run a drift of sufficient cross section to permit the construction within its limits of the common center wall, and after this wall had been placed, to start the heading of the twin tunnels, thus utilizing the massive core of concrete both as a guide and as a basis for the excavating and concrete work to follow.

The 10 feet 5 inch by 14 feet center headings were carried through on the Detroit side without the use of air pressure, but all the work was heavily timbered as rapidly as the headings advanced. On the Canadian side difficulties were encountered in the blue clay through which the headings advanced, and on account of this condition a shield was used in driving the center heading on a portion of the approach tunnels. The design of this shield, which was rectangular in shape, having a total height of 16 feet 5⅜ inches and a total width of 12 feet 4⅛ inches, does not concern us here. Suffice to say that work on the drift with this shield was advanced sufficiently far to permit the excavation of the center wall. The character of the clay, however, required the entire sides and roof of the bore to be heavily timbered. After the center wall had thus been constructed a sufficient distance in advance, the side shield shown in Fig. 4 was used for the remaining excavation.

Four of these shields, built according to the same general design were in operation, one in each of the two headings being advanced on both sides of the river. These shields are slightly more than half cylinders 27 feet 1½ inches in diameter. The cutting edge is confined to the circular portion and the shield is advanced by twenty-one 8-inch hydraulic jacks placed around the cutting edge. Although the course of the shield can be determined to a certain extent by these jacks, it is necessary to guide chiefly from the finished center wall. Under normal conditions the weight of the shield and its load are carried by the lower portion of the curved section of the casing, which has a total width of 13 feet from the cutting edge to the rear of the shield. Two heavy shoes, having their faces vertical, are mounted on the outside of the verticle section of the shield, one near the top and the other close to the bottom, and bear against the rear face of the web of a 12-inch steel channel set horizontally in the concrete of the center wall. To provide for emergencies a third shoe with its face horizontal is mounted on a heavy knee brace on the vertical section of the shield in a position directly over the bench on the center wall.

The excavation made in connection with the shield is lined immediately in the rear of the latter with continuous rings consisting of 4-foot segments cut from 12 inch by 12 inch maple and beech timber wedged in place to insure a lining fully capable of carrying the load until the concrete has been placed and received its set. This lining of timber rings is finished with a ring of 2-inch by 2-inch beech lagging to give a smooth surface for the waterproofing, which consists of three-ply roofing felt laid in hot straight run coal tar pitch. The arch of the tunnel is built in 12-foot sections after the invert and side walls have been constructed. The inverts and side walls are built by the use of removable steel forms made in sections 2 feet wide of 3-16-inch plates with a 2-inch by 2-inch by ¼-inch angle riveted along both sides of each three-foot section and horizontally riveted along both to stiffen them. The arch forms also consist of steel ribs built up of two angles and a plate with these ribs spaced 3 feet 9 inches apart on centers and lagged with 3-inch plank attached to them by wood screws. The arch forms are advanced in 12-foot sections by means of a traveler car.

Subaqueous Tunnels—The soft ground constructed with a side shield shades insensibly into the subaqueous tunnel, and indeed, so far as modern practice indicates, the chief difference between a soft ground tunnel through heavy water bearing strata and a subaqueous tunnel in soft material is the feature of hydrostatic head and the necessity for the employment of compressed air at high pressure, not as a matter of expediency and to avoid possible difficulties, but as a matter of necessity in view of conditions always present. The hydrostatic pressure increases with the diameter of the tunnel and is always greater at the bottom than it is at the top and its action needs very careful attention in tunnel design and in tunnel driving.

In the construction of subaqueous tunnels the thing chiefly to be desired is to get the roof of the tunnel as high as possible and its depth below mean low water is usually fixed by the harbor regulations which apply in the particular locality where the tunnel is built; as for example, in New York City the harbor regulations require a minimum depth

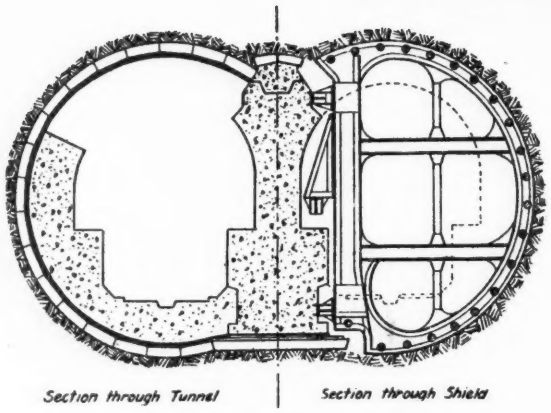

Fig. 4—Sand Tunnel, Detroit River.

of 40 feet from mean low water to the top of the structure. The higher the roof of the tunnel can be made, the slighter are the grades necessary in approaches and the smaller, as a rule, the expenses of construction, it being sometimes possible to remove a large portion of the material by dredging methods rather than by mining. A smaller depth of water over the tunnel also means a lesser hydrostatic head and consequently a thinner tunnel lining. The danger in having the roof of the tunnel too close to the stream bottom arises from the usual treacherous character of the material, as blowouts may occur during its construction and the tunnel be drowned out entirely. These blowouts may take place through rock fissures or in soft material bodily throughout the entire mass.

The character of the material in the bottom of the stream has, therefore, a large bearing upon methods of subaqueous construction, and subaqueous tunnels may be classified in accordance with the methods which have been taken to overcome unstable conditions into three classes, which are:

1. The Closed Caisson and Excavating Method.
2. The Closed Caisson and Dredging Method.
3. The Shield Method.

With the first two of these it is not necessary at all that the material in the river bottom should be firm or that the tunnel bed should be below the bottom of the stream more than a sufficient distance to insure a firm foundation. Under the shield method the tunnel must either penetrate firm strata below the river bottom or else an airproof blanket be deposited over its entire extent.

The Closed Caisson and Excavating Method.—Hhe Harlem River Tunnel of the New York Subway System, built in 1903, passes under the Harlem River through mud, silt and sand, the latter flowing with remarkable ease when wet. Between bulkhead lines the river, 26 feet deep, is 400 feet wide, but for 610 feet the tunnel is made of two cast iron cylinders imbedded in concrete. Mr. D. D. McBean, of the sub-contracting firm of McMullen & McBean, devised the following plan for its construction:

He proposed to enclose the space to be occupied by the tunnel by two lines of specially constructed 12 in. tight sheet piling. Upon these lines of piling cut to the proper level he would lay a timber roof of three layers of 12 in. by 12 in. timbers separated by courses of 2 in. planks running at right angles, making the roof 40 in. thick. Under the protection of the box so made he proposed to excavate the material either with or without the use of compressed air.

In the execution of this plan the river was first dredged so as to leave an average depth of 7 or 8 feet of material to be removed. Four rows of piles were driven 6 ft. 4 in. apart center to center transversely and 8 ft. 4 in. apart longitudinally. They were cut off and capped to support the heavy

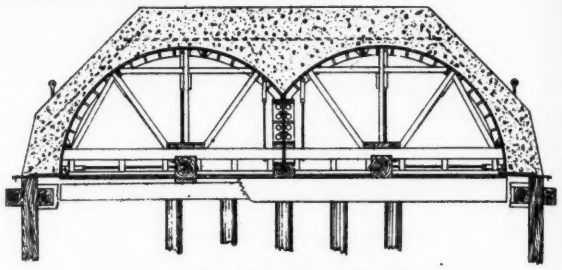

Fig. 5—Harlem River Tunnel.

timber roof and the interior bracing system and eventually were to be cut off at sub-grade to further support the finished tunnel. A line of 12 in. by 12. sheet piling was then driven along each side of the tunnel in careful alignment guided by a floating wale frame, steel pilot piles being further used to secure accuracy in driving. With the sheeting in place, the 40 in. thick timber roof, supported on six lines of 12 in. by 14 in. range timbers bolted to their bottoms, was floated into position, and when it was sunk these timbers rested exactly upon the two rows of sheet piling and the four inner rows of round piles. The sunken roof was next overlaid with about 5 feet of earth dredged from the immediate vicinity to bring it to a firm bearing and to provide weight against the uplifting tendency of the air pressure. Each end of the box so formed was closed by suitable bulkheads, making the length of the timber 216 feet, or about half the width of the river, the other half being left open for navigation. When the water was driven from the working chamber formed within the box by compressed air, the leakage was found to be small and the sheeting in excellent alignment. The material inside was excavated with little trouble and the tunnel lined and concreted.

For the building of the second half of the tunnel Mr. Mc Bean was convinced that a more economical form of construction could be devised by the substitution of the upper half of the tunnel itself for the heavy timber roof, especially as the timber roof had no function to perform after the completion of the tunnel. Fig. 5 shows the method by which the second half of the tunnel was constructed. The system of tunnel excavation after this method has been covered by letters patent. As before the site was dredged to nearly subgrade and a double line of 12 in. by 12 in. sheeting driven to form the sides and ends of the submerged box, but the sheeting was now cut off at the springing line of the tunnel to form a footing for the roof, which was built in three sections, two 90 feet long and one 84 feet long, in a floating box 106 feet long, 35 feet wide and 12 feet deep. The bottom of this box was made of 12 in. by 12 in. transverse timbers laid 4 feet apart and floored with 3 in. by 12 in. plank. On three 4 in. by 12 in. longitudinal timbers fastened to the floor of this box was then built a false floor for the upper half of the tunnel made of 16 in. by 16 in. transverse timbers 8 feet apart carrying a center longitudinal sill of 10 in. by 16 in. timber and two side sills of 16 in. by 16 in. timber 6 ft. 3 in. from the center line. The space between these longitudinals was floored with 2 in. plank. Upon this false floor the cast iron tunnel was erected in 6-foot rings. Rods and braces were introduced as a precaution against any possible deformation, and suspension bars were built through special cast iron and plate brackets. The roof was then covered with concrete tied together by impedded reinforcing rods as a further precaution. Each 6-foot ring of the iron shell weighed about 31,000 pounds and carried 618 cubic feet of concrete. It was estimated that the total weight of the iron, concrete floor, etc., was about 50 pounds per lineal foot less than the estimated buoyancy of the empty roof chamber. When everything was ready derrick boats were run along

the side of the roof, then needle beams, floor, etc., lifted, and submerged box floated out from underneath and the roof lowered into its final position. At convenient intervals in the roof openings had been left for the descent of the workmen and for the removal of material. The excavation went on underneath the roof, which, with the lines of piling, formed a waterproof working space for the workmen. After the excavation had been completed under compressed air the interior of the tunnel was lined with concrete, and the end bulkheads, surplus wood, etc., removed, leaving a reinforced concrete tunnel tube. The entire work was completed under the very low air pressure of 10 pounds per square inch.

In this system of tunnel construction any shape desired may be given to the cross section, also any combination of metal tubes and concrete, either plain or reinforced, can be employed. A twin double track tunnel may be built as readily as a single tube, and such a double track tunnel built as a single tube would possess materially increased rigidity and resistance to vibration under passing trains. This system also permits a much more rapid rate of working than is possible with other methods and provides ample opportunity for any kind of foundation desired underneath the structure.

One of the disadvantages of this method of construction is the excessive weight of the cast iron tunnel segments which have to sustain, in this method of construction, tensile stresses for which they are not perfectly adapted and which require, therefore, an excess weight of material. To obviate these tensile stresses to some degree it is necessary that the flalse floor be made exceedingly heavy. In addition the design of the section for a double track tunnel is such as to entail a considerable excess of concrete. To obviate these disadvantages and to utilize as well the known advantages of steel in all classes of building construction the design shown in Fig. 6 has been proposed by the Carnegie Steel Company. This design is for the construction of a subway boulevard 60 feet wide having a central column adjacent to which run two street car tracks separated from the roadways by ornamental railing. This tunnel can be constructed after the McBean system by driving wooden side sheeting, or steel sheet piling, building the steel and concrete roof in pontoons and floating into position. Excavation can then be made in perfect safety and convenience under the roof, which is connected by a water-proof metallic seal to the sheet piling. The foundation for the tunnel will be constructed on round timber piles driven with floating equipment at convenient intervals across the tunnel side. The center piles should be longer than the others in order to allow the crown of the tunnel roof to rest upon them during construction. The steel work is figured for vertical stresses only: horizontal stresses will pass through the concrete and be resisted thereby. Girders would be shipped in two pieces and in erection would be riveted together over the columns and to the 18-in. distributing beams at their ends. They will then be assembled in sections and fastened together by chains from one end of one girder to the opposite end of the next so as to prevent separating when lowered into position. These chains are figured for about 88,000 pounds thrust in the girder and are to be connected by clevices to 1-inch plates between the girders and the distributing beams. This will cause the girders to act as arches during erection. After the sections are lowered into their position and the working chamber opened it will be desirable to excavate the center portion to put in grillage and columns before the side portions are removed. In order to cut down the amount of concrete required it is placed after the manner of floor arches in buildings. The estimated weight of the steel required, including the columns, the girders, the grillage, etc., is 7,900 pounds per running foot.

The Closed Caisson and Dredging Method.—A somewhat similar method of construction has been followed in the tunnel crossing under the Seine river by Line No. 4 of the Metropolitan Railway of Paris. The total length of the tunnel is 3,584 feet, of which 2,038 feet were driven by the shield method, 1,320 feet by the submerged caisson and 226 feet by the freezing process. The tunnel is lined with cast iron segments and the same method of lining pertains through the shield driven tunnels, the length built by the freezing process and that built by the caisson method. Three caissons, as shown in Fig. 7, were sunk end to end to form the crossing of the main stream, two others to form the crossing of a smaller branch, while three were sunk to form each of the two stations.

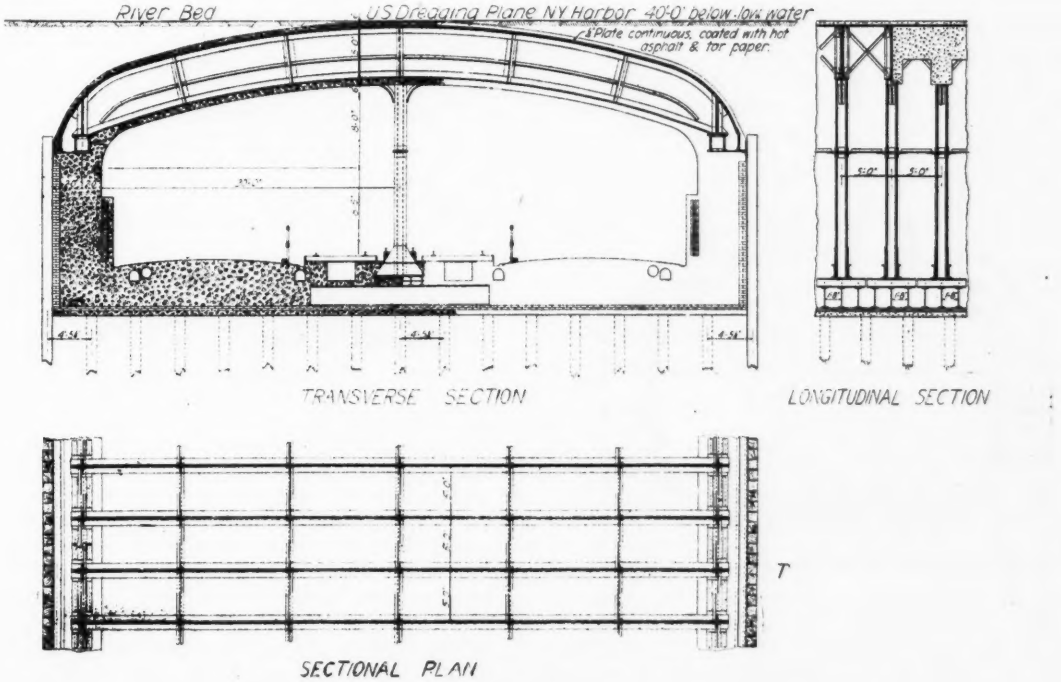
River Bed
U.S. Dredging Plane N.Y. Harbor 40'-0" below low water
¼" Plate continuous, coated with hot asphalt & tar paper.
TRANSVERSE SECTION
LONGITUDINAL SECTION
SECTIONAL PLAN

Fig. 6. Tunnels Subaqueous.

The three river caissons were 118, 126 and 142 feet long respectively and the two caissons for the smaller crossing were each 66 feet long. The caissons were made of structural steel ribs braced together by longitudinal frameword consisting of heavy I-beams and short members made of steel angles. The frames were continued below the elevation of the floor to form the working chamber beneath the caisson. The entire framework, including the ends, was covered with steel plates so that when finished the caissons had flat sides and ends and an elliptical top. After erection the caissons were launched and towed into position between pile stagings, which served the double purpose of guiding their descent and forming a working platform. Previous to this sinking the portion of the river-bed to be occupied by the caisson had been leveled by dredging. Once in position the cast iron segments were erected within the framework and the annular space between the lining and the shell filled with concrete, gradually sinking the caisson to the river bottom. As the sinking progressed the working shafts were placed in position, air pressure applied and the excavation proceeded with underneath the cutting edge of the caisson. No special difficulty was experienced in sinking the caisson aside from the hardness of the material which had to be broken up by blasting. A space was left between the successive caissons of about 5 feet and it was proposed to close this space by building in a section of lining and steel envelope.

A similar method was followed in the construction of the subaqueous portion of the Detroit River Tunnel, of the Michigan Central Railroad, 2,622½ feet in length. The construction adopted was to build the entire length in ten sections of riveted twin tubes 23 feet 4 inches in diameter built on shore, floated into position and sunk with the aid of air cylinders to position on a steel grillage with alignment beams laid in a dredged trench with a maximum bottom width of 48 feet and a depth of 32 feet, one such grillage coming at each joint. The arrangement of the completed tubes and the steel frame is shown in Fig. 8. The steel tubes were made of ⅜-inch plates with caulked lapped joints having double rows of ¾-inch rivets. The exterior of each tube was reinforced with transverse vertical diaphragms 12 feet apart made with ⅜-inch plates reinforced by pairs of 3½-inch by 3½-inch angles on the outer edges. The shape of the plate conformed to the cross section of the concrete jacket, the lower edge being horizontal to serve as a cradle supporting the tubes on the steel grillage in the trench. Intermediate between the diaphragms were inside 3-inch by 3-inch flange angles with connection for twelve 1-inch adjustable radial rods connected to a center ring to provide interior bracing and to prevent deformation in handling. Before launching each end of each tube was temporarily closed with a timber

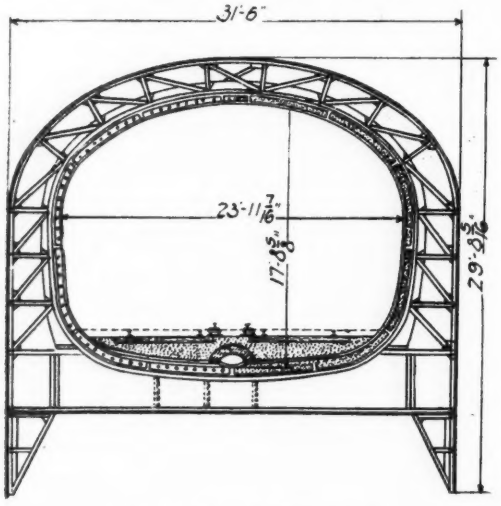

Fig. 7. Tunnels Subaqueous.

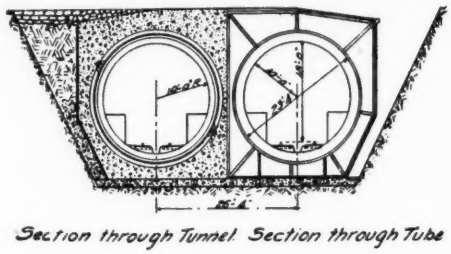

Fig. 8. Detroit River Tunnel.

bulkhead taking bearings against 3½-inch by 3½-inch inner flange angles of the tube. A pair of tubes 262½ feet long altogether, weighing about 550 tons, were launched transversely and floated into position between rows of guide piles about 30 feet each side of the center line of the tunnel. Each tube was equipped with two horizontal steel air cylinders about 10 feet in diameter and 60 feet long temporarily secured with adjustable chains to cradles in the diaphragms, as indicated in the general elevation.

The upper end of the trench in which the steel tubes lie was excavated by a dipper dredge and the lower part by a clam shell dredge provided with a specially designed clam shell bucket. The bottom was approximately leveled and the steel grillages sunk into approximately accurate position to receive the steel tubes. After the tubes had been centered over the grillages they were sunk into position by opening inlet valves in the lower part of the bulkheads and outlet valves in the upper parts; water enters through the former causing the tubes to sink slowly. Enough water was admitted to sink the tubes below the surface until the air cylinders on top commenced to be submerged, maintaining the tubes in a horizontal position and preventing them from sinking further until their buoyancy was overcome. They were thus maintained in an even balance and gradually lowered to the bottom under perfect control without danger of severe stresses or distortion. Aftr the sections were sunk and adjusted to exact position concrete was filled beneath and around the tubes, forming a monolith concreae structure in which are two steel lined tubes 23 feet 4 inches inside diameter. This concrete is deposited under water through steel tremies in an outside form with vertical walls, between which and the sides of the dredged trench the space was backfilled. After the outside concreting was in place the tubes were lined with concrete 20 inches in thickness.

The underlying principles of the construction are as follows:

The steel serves first as a form for confining the outside concrete deposited through the water and later forms a perfect waterproofing for the completed tunnel. The outside concrete is of sufficient dimensions and strength to resist hydrostatic pressure when the water inside the steel tubes is pumped out in order to enable workmen to go inside and construct the tunnel proper without the employment of compressed air. The outside concrete fills up all depressions and irregularities in the bottom of the tunnel trench and makes, so to speak, its own bed. This will eliminate any tendency to settlement after the tunnel is completed and in use, and if the bottom has a tendency to yield or settle, it will do so while the outer concrete is being deposited rather than after the tunnel is completed. The tunnel proper, which is built inside of the steel shell and the outer concrete casing, is of sufficient strength to resist all loads, whether hydrostatic, static or live, which may come upon it. It can be built in long sections at a time and under a strict and reliable system of inspection.

(Continued on Page 143)

The Signal Department

Railway Signal Standards

No. 3 The New York, Ontario & Western

This road uses two position, lower quadrant, normal clear automatic block signals. There are in service both electro-motor semaphore and uninclosed disk (clock work) signals, but only the semaphore signals, as representing modern practice, will be considered. A two arm, home and distant signal is shown in Fig. 59. The arms have a stroke of 60°. The upper or home blade is painted red aad the lower or distant blade green. The night color indications are red for stop, green for caution, and white for clear. The general design of the spectacle is shown in the figure. As indicated, the mechanism is in a case at the base of the post.

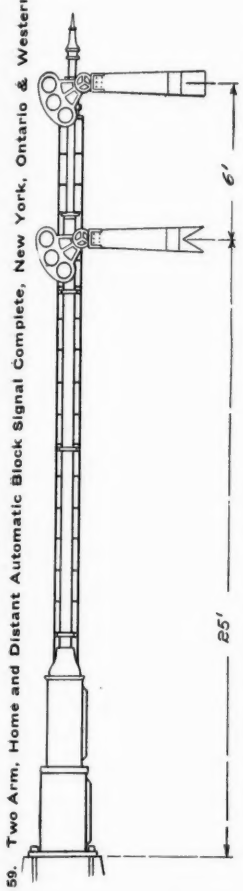

Fig. 59. Two Arm, Home and Distant Automatic Block Signal Complete, New York, Ontario & Western.

Signals are operated by a caustic soda or potash battery housed either in the case at the base of the signal below the mechanism or in a concrete box, Fig. 60. This box has a concrete roof reinforced with engine stack wire, and a cover made of 3-16-in. boiler iron, which swings on hinges embedded in the concrete of the sides. The general dimensions are shown in the figure.

Track battery consists of 4 cells of gravity in series—parallel housed in iron chutes. There are from 4 to 8 celles per section of track, depending on the length of the circuit.

Fig. 61 shows the arrangement of concrete signal foundation, chute and battery box at a signal location. An end view of a signal (on the right) and relay box mounted on a post attached to a chute for a cut section (on the left) together with wooden trunking and bootlegs for track wires is shown in Fig. 62.

The present standard for wire ducts, as shown in Fig. 63, consists of fiber conduits. Here are also shown the same apparatus as in Fig. 61 with track, insulated joints and conduit added. A detail view of the conduit boot-leg with wires bonded to rail is shown in Fig. 64. The conduit riser is fitted with a cap and is held in place by an iron strap fastened to two ties. The wires are brought out on the side away from the rail and bent around the conduit. As shown in Figs. 61 and 62 the wire ducts are taken up through the signal foundation to admit the wires to go to the signal mechanism. All ducts are placed below ground.

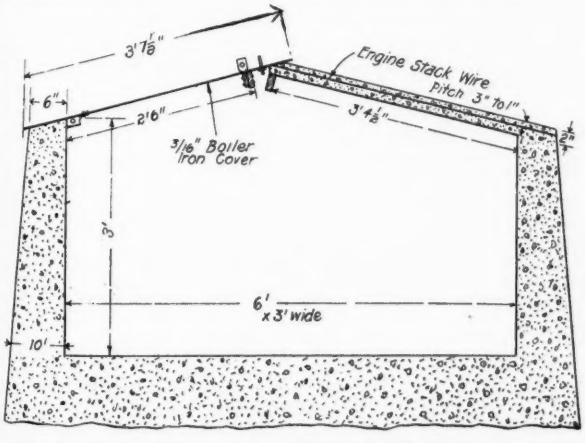

Fig. 60. Concrete Battery Box, New York, Ontario & Western.

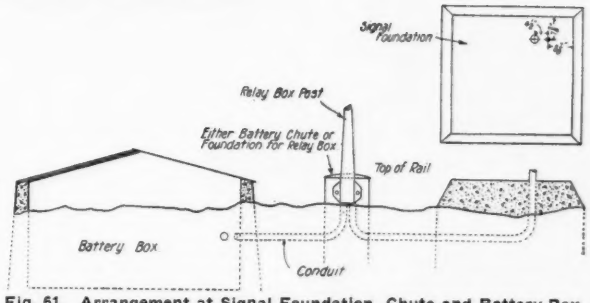

Fig. 61. Arrangement at Signal Foundation, Chute and Battery Box, New York, Ontario & Western.

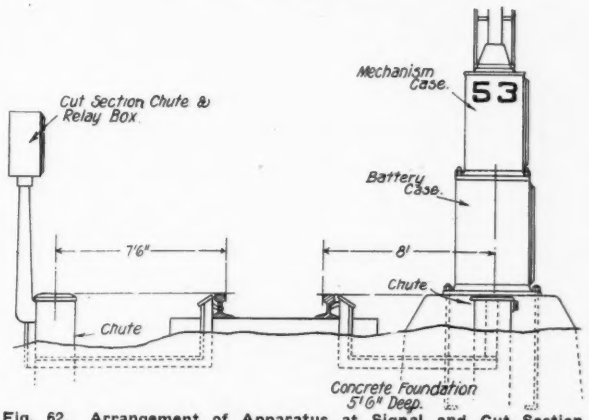

Fig. 62. Arrangement of Apparatus at Signal and Cut Section Locations, New York, Ontario & Western.

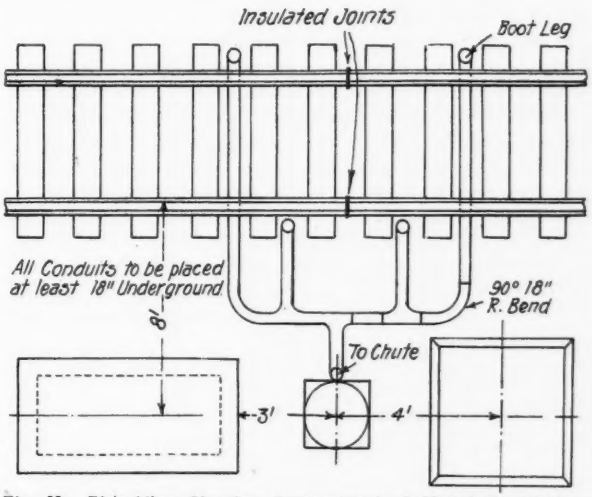

Fig. 63. Plan View Showing Arrangement of Signal Foundation, Chute, Battery Box and Conduit Leads to Track, New York, Ontario & Western.

The wires are bonded to rail is shown in Fig. 64. The conduit riser is fitted with a cap and is held in place by an iron strap fastened to two ties. The wires are brought out on the side away from the rail and bent around the conduit. As shown in Figs. 61 and 62 the wire ducts are taken up through the signal foundation to admit the wires to go to the signal mechanism. All ducts are placed below ground.

Fig. 65 illustrates the method of mounting a cast iron relay box on an iron post embedded in a concrete foundation.

Insulated joints are of the angle bar type. Details of the fiber parts appear in Fig. 66.

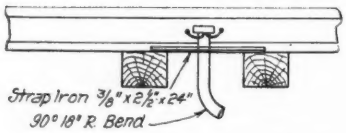

Fig. 64. Conduit Bootleg, New York, Ontario & Western.

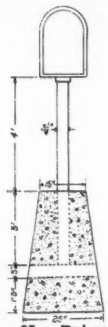

Fig. 65. Relay Box and Post on Concrete Foundation, New York Ontario & Western.

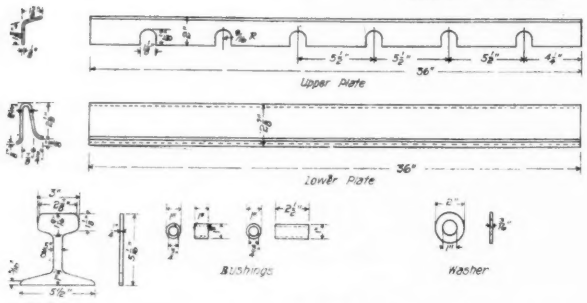

Fig. 66. Fiber Details of Insulated Rail Joints, New York, Ontario & Western.

Fig. 67 illustrates the method of conducting wires from pole line to apparatus. Fiber conduit is fastened to the field side of the pole and terminates in a 180° return bend to prevent rain or other moisture from entering. The conduit is held in place by iron straps. The relative position of the various line wires used in single track signaling is shown in Fig. 68. All the apparatus provided for is, of course, not always used. Western Union standard practice is followed in the erection of the line and in the class of pins, insulators, crossarms, braces, and other material used. A separate pole line is provided for signal circuits.

Switches are insulated by cutting a section out of the gage plate and equipping the roads in a manner very similar to that shown in Fig. 42. A complete insulated switch appears in Fig. 69.

On double track the polarized track circuit is used, Figs. 70, 71. The home signal arm is controlled by the neutral armature of the polarized track relay and the distant signal arm by the polarized armature which responds to the action of a pole changer, actuated by the home signal in advance. A wiring diagram for a track relay at a two arm signal thus controlled is shown in Fig. 72, a similar diagram for a track relay at a relayed cut section in Fig. 73 and Fig. 74 shows the local wiring between the track and relay. No switch indicators are used on double track.

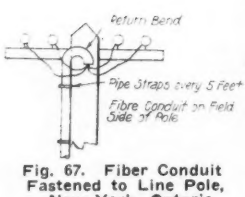

Fig. 67. Fiber Conduit Fastened to Line Pole, New York, Ontario & Western.

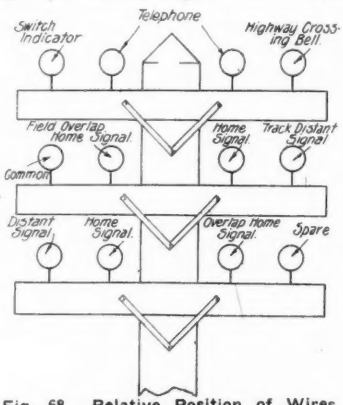

Fig. 68. Relative Position of Wires on Crossarms, New York, Ontario & Western.

On single track, signals are arranged as shown in Fig. 75. All signals do not, however, have two arms, but a distant signal is always provided for each home signal.

Semaphore switch indicators are provided at all switches on single track. They are arranged to announce a train when it is approaching the distant signal for the block in which the switch occurs. Typical circuits for the control of signals and switch indicators on single track are shown in Fig. 76. It will be noted that a separate battery is provided for the line circuits. This battery is of the same class as that used to operate the signals. All circuits are neutral. Separate relays and line circuits control the home and distant signals. The home signal control circuit breaks through the points of all the track relays of the sections through which it governs, but the distant signal control circuit is controlled only by a circuit controller on actuated by the home signal in advance.

At interlocking plants in automatic block signal territory, the home signals are mechanically operated, but are made semi-automatic by the use of an electric slot.

Track relays are of 5 ohms and 9 ohms resistance, depending on the length of track section and other local conditions. They are of the enclosed type, conforming to the specifications of the Railway Signal Association.

The following classes and sizes of wire are standard. Line wire is No. 12 B. & S. gage grade, "A", copper-clad steel, weatherproof insulation with one brade. Bootlegs are made of No. 10 B. & S. gage rubber-covered copper wire, as are leads from track to apparatus and from battery to mechanism. Leads from pole line to apparatus are made of No. 12 B. & S. gage rubber-covered copper wire and No. 12 B. & S. gage rubber-covered flexible copper wire is used in chutes.

No. 4. The South Side Rapid Transit Co., of Chicago.

This road is operated by electricity at 650 volts and has only a small number of automatic block signals, but is none the less interesting, as it illustrates the earlier methods employed under such conditions: i. e., the use of direct current track circuits on an electric railway. All the signals are single arm, two position, lower quadrant, normal clear, electro-pneumatic dwarfs, Fig. 77. The stroke of the arm is 60°. Blades are painted red and the night color indications are

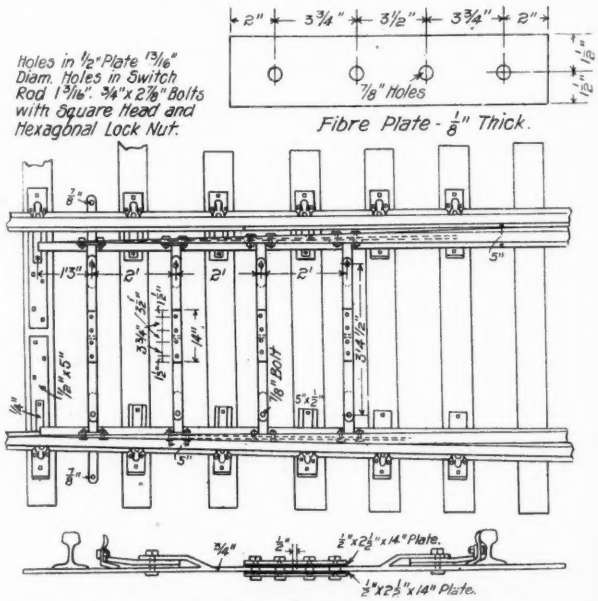
Holes in 1/2" Plate 13/16" Diam. Holes in Switch Rod 1 3/16". 3/4" x 2 7/8" Bolts with Square Head and Hexagonal Lock Nut.
2" 3 3/4" 3 1/2" 3 3/4" 2"
7/8" Holes
Fibre Plate - 1/8" Thick.
1/2" x 5"
7/8" Bolt
5" x 1/2"
1/2" x 2 1/2" x 14" Plate.
1/2" x 2 1/2" x 14" Plate.

Fig. 69. Insulated Switch, New York, Ontario & Western.

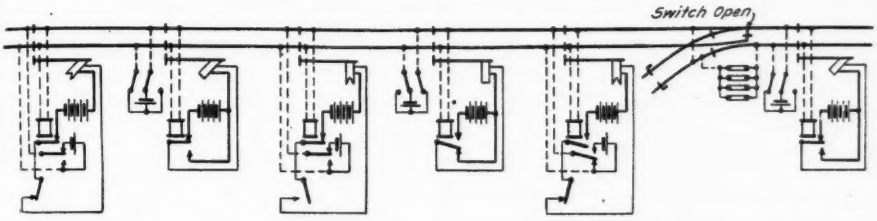

Fig. 70. Single Arm Home and Distant Automatic Block Signals on Double Track Controlled by Polarized Track Circuit, New York, Ontario & Western.

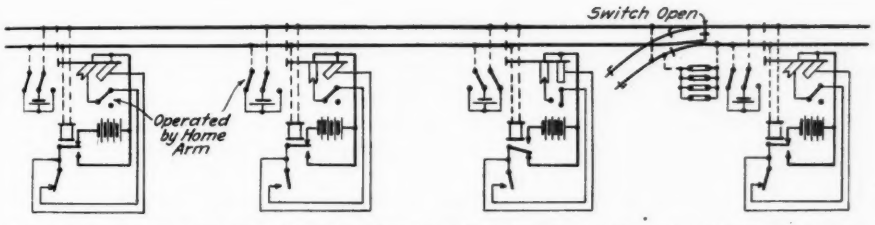

Fig. 71. Two Arm Home and Distant Automatic Block Signals on New York, Ontario & Western. Double Track Controlled by Polarized Track Circuit,

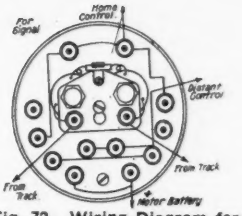

Fig. 72. Wiring Diagram for Track Relay at Two Arm Automatic Block Signal Controlled by Polarized Track Circuit, New York, Ontario & Western.

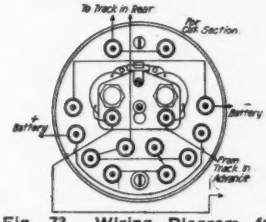

Fig. 73. Wiring Diagram for Track Relay at Relayed Cut Section, Polarized Track Circuit, New York, Ontario & Western.

green for clear and red for stop. No distant signals or switch indicators are used.

Track circuits and control circuits are fed from storage battery charged from the third rail through a resistance. The same battery feeds both line and track. No line relays are used, as the control magnets take current direct from the "line." All signals are on a third main track, used for traffic in both directions, but without overlaps, as no opposing movements are permitted.

Two track relays are used for each track circuit, one of 16 ohms resistance at the battery end and one of 4 ohms resistance at the other. A grounded return circuit is used. Bootleg wires are No. 9 B. & S. gage rubber-covered copper and all other wires are No. 14 rubber-covered copper. Resistances introduced into the various circuits reduce the voltage to that required for proper operation. All control circuits are broken through controllers on switches.

Typical circuits are illustrated in Figs. 78 and 79, which are continuous with each other. A section of the road protected by automatic block signals is shown in Fig. 80.

On February 3, seventeen shovels working in the Culebra Construction District of the Central Division, excavated 25,274 cubic yards, an average of 1,487 cubic yards for each shovel during the eight hour working day. The total number of hours under steam was 136, asd the total number of hours that the shovels were actually loading was 93 hours and 20 minutes. These shovels loaded 1,256 Lidgerwood flats and 141 ten-yard Western dump cars, a total of 1,397 cars.—The Canal Record.

Natural Relations Between State and Industrial Corporations.

Co-operation is the first requisite to civilization and presupposes an understanding between two or more persons having a common interest to serve.

We can readily imagine the beginnings of co-operation in an agreement between two savages to protect each other against a giant too strong for either alone, and this experience of benefit from the standpoint of defense would soon suggest its offensive value and also the value of added numbers.

But with the increase in numbers, the danger of misunderstandings and the difficulty of maintaining entire mutuality of interest increased also, and it must soon have been realized that either the individual must be willing to sacrifice something of his own freedom of action and wishes, or he must abandon the possibility of greater gain through more perfect and extensive co-operation.

Here entered a new factor—the determination of the physical majority to compel the minority to accept this renunciation of freedom of action for the common good, or, sometimes, for the good of the ruling faction.

As the bands swelled to tribes and the tribes to nations, countless difficulties sprang up in the way of establishing a basis of co-operation that would be acceptable to a large enough proportion of the population to be enduring.

*By M. L. Byers, Ch. Eng. M. of W., Mo. Pac. Ry., before the St. Louis Railway Club.

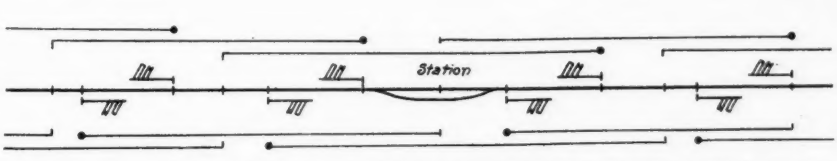

Fig. 75. Overlaps and General Arrangement of Automatic Block Signals on Single Track, New York, Ontario & Western.

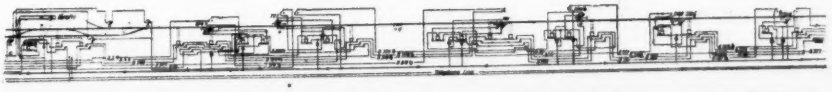

Fig. 76. Typical Circuits for Automatic Block Signals and Switch Indicators on Single Track, New York, Ontario & Western.

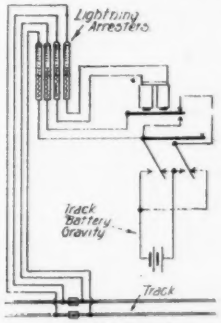

Fig. 74. Local Wiring for Relayed Cut Section, Polarized Track Circuit, New York, Ontario & Western.

The necessity for coercing the unwilling into respect for the wishes of the dominant faction and also the fact that most early governments were for defensive or for offensive purposes, led to the use of an organized permanent police or soldiery, and the command of these gave opportunity for the establishment of autocratic instead of democratic government.

Usually this meant government of the many for the benefit of the few, and this resulted in ages of struggle of the ignorant, unorganized many to escape from the exploitation of the intelligent few intrenched behind all the mechanism of government and with the advantage of expenience, wealth and strategic position.

Slowly, but surely, the many have gained in the struggle, especially in the case of the Anglo-Saxon races.

How slow the gain has been may be seen from the fact that it was not until the year 1215 that King John of England was forced to promise his subjects in the Great Charter then signed by him that, among other things, "No freeman shall be seized or imprisoned or outlawed or in any way brought to ruin: We (the King) will not go against any man nor send against him, save by legal judgment of his peers or by the law of the land."

"To no man will we (the King) sell, or deny, or delay, right or justice."

"No scutage (a form of tax) or aid shall be imposed in our realm save by the common council of the realm."

"We (the King) will grant that . . . . all cities and boroughs, and towns, and ports, have all their liberties and free customs."

Consider what must have been the state of human liberty when renunciations like these it was necessary to wrest by force of arms from the King!

When our fathers assembled in the First Continental Congress in 1774 to devise ways and means to better their conditions, they found in effect a very unsatisfactory series of co-operative systems or governments for conducting the affairs of the inhabitants of the then British Colonies of America.

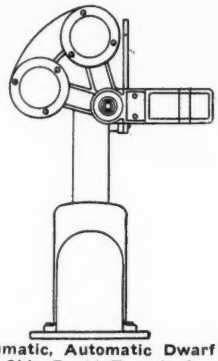

Fig. 77. Electro-Pneumatic, Automatic Dwarf Block Signal, South Side Rapid Transit Co.

The character of their objections can be largely gathered from the famous Declaration of Independence where, among other statements, we find that "The history of the present King of Great Britain is a history of repeated injuries and usurpations, all having in direct object the establishment of an absolute tyranny over these States."

"These States" referred to were thirteen in number and each had a seperate co-operative system, or government, as we usually term it, all subordinate to the power of Great Britain and being divided into three classes. Pennsylvania, Delaware and Maryland had been originally settled by emigrants under the direction of great proprietors who had been

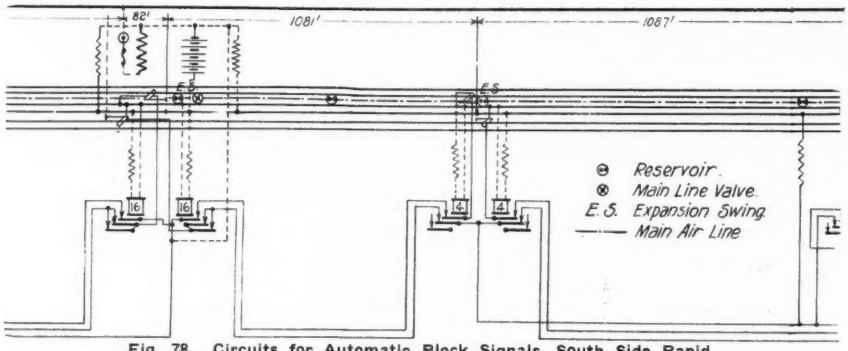

Fig. 78. Circuits for Automatic Block Signals, South Side Rapid Transit Co.

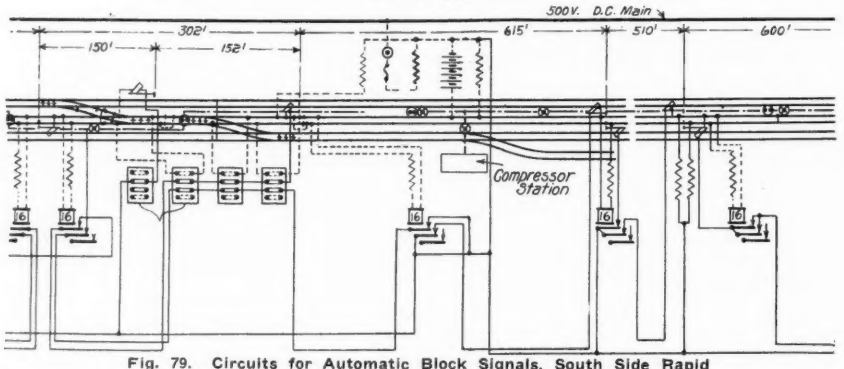

Fig. 79. Circuits for Automatic Block Signals, South Side Rapid Transit Co.

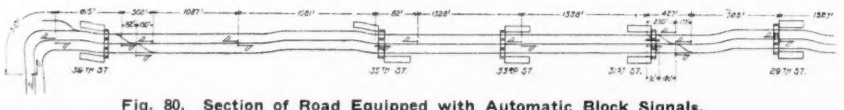

Fig. 80. Section of Road Equipped with Automatic Block Signals, South Side Rapid Transit Co.

given title to all the land by the King, and also had been given by him the apthority to govern the settlers. Much of the land they sold, but their heirs retained title to the remainder just as our Government to-day retains title to the public lands it has not yet sold or given away. Further, these heirs continued to appoint the governors of these provinces.

Connecticut, Rhode Island and Massachusetts had been granted charters by the King in times past and practically governed themselves except as they were interfered with by the supreme authority of the British nation; in fact, so satisfactory was their form of government that Rhode Island did not adopt a State Constitution until 1848.

The other States were Crown Colonies; the King appointed the governers and the council, leaving the people little voice in the government.

A successful revolution placed in the hands of the Colonists the means of experimenting on the creation of a satisfactory system of co-operation in the conduct of their affairs after their destruction of the unsatisfactory one and the result was a Confederacy of the thirteen colonies as agreed upon in the Articles of Confederation adopted July 9, 1778, and lasting until 1789, by which time the invention had proved a total and mortifying failure and a convention to make a second attempt had been assembled.

This Constitutional convention assembled on May 14, 1787, and its work went into legal operation on March 4th, 1789.

By 1804, twelve amendments had been made, practically rounding out the work of the convention, the next amendment not being made until 1865.

The prime cause of the failure of the Confederation was the lack of a strong central government, and the reason for this omission was the dread of the people lest they devise a mechanism of government which some day some usurper could and would turn against them.

In the Constitution, every precaution was taken in the way of preventing uncontrolled power from resting in the hands of any single officer. The President does not make but merely executes the laws; the Congress is held in check by the provisions of the Constitution, and the courts see that these are respected; the officering of the volunteer army is in the hands of the States; and finally, the Constitution provides specifically that "the right of the people to keep and bear arms shall not be infringed."

The protection of the Individual and of his Property Rights against despotic acts of government were objects ever before the members of the convention.

The Preamble to the Constitution reads, "We, the people of the United States, in order to form a more perfect union, establish justice, insure domestic tranquility, provide for the common defense, promote the general welfare, and secure the blessings of liberty to ourselves and our posterity, do ordain and establish this Constitution for the United States of America."

About seventy-two per cent of the Constitution as modified by the first twelve Amendments is taken up with outlining the creation, perpetuation, and operation of the machinery of government and the relations between State and Federal authority. Twenty-five per cent is occupied with restrictions and regulations designed to safeguard personal liberty and property rights. Less than one per cent is occupied with the relations of Government to Commerce and Industry, this part being confined to the following: "The Congress shall have power . . . . . .

"To regulate Commerce with foreign nations and among the several States, and with the Indian tribes."

"To establish post-offices and post-roads."

"To promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."

As to Commerce, there was little except some coasting trade. Industry was still largely a matter of individual effort, co-operation being practically confined to partnerships, and these not being of importance.

It must be kept in mind, also, that the Government, as finally designed, was still a compromise and it necessarily contained the defects and lack of consistency that compromise always compels.

The relations between Federal, State and Municipal government had been much discussed and were finally compromised, to be later the subject of further endless discussion, and finally of Civil War. Lincoln with his wonderful faculty for limpid statement gave the common-sense relation in a sentence, "Whatever concerns the whole should be confided to the whole—to the general government: whatever concerns only the State, should be left exclusively to the State."

Since the Constitution casually mentioned foreign and interstate commerce, the postal service and patent laws as being deserving of Federal attention, there have appeared upon the world's stage the steam engine, the steamship, the steam railroad, the electric motor, the electric light, the telephone, the wireless telegraph and telephone, the modern power printing press, the sewing machine, the flying machine, the blast furnace and the steel converter, the coal oil refinery, the cotton-spinning machinery, and, in fact, all the host of modern labor-saving inventions.

All of these called more and more loudly for co-operation of many persons to a common end, and it became necessary to design more and more complicated machanisms of co-operation. The INDUSTRIAL COPORATION added itself to the already existing Federal, State and Municipal Corporations or Governments, all created by the people for the purpose of enabling them to effect by co-operation what could not otherwise be accomplished.

It is pertinent to inquire why, if Federal, State and Municipal Governments are merely mechanisms designed for the purpose of enabling the People to co-operate to secure certain results, and Industrial Corporations are also merely mechanisms designed for this same purpose of enabling the People to co-operate to secure certain results, then why not do away with the Corporations and do all the co-operating through the already existing Governmental mechanisms?

Is there any fundamental difference in the design of these two classes of mechanisms that especially fits one class for certain kinds of co-operation while unfitting it for other classes, and if so what is this difference and what are its effects?

That such fundamental difference in design exists, there can be no doubt, and long experience has demonstrated the need for this difference in order that the two classes of co-operative problems may be successfully coped with.

Both the Governments and the Corporations are designed to be controlled directly or indirectly by popular vote, i. e., by the vote of the people interested therein, but the Governmental Mechanism is controlled by a vote based on the vote to the man—one man, one vote; the Industrial Corporation, on the other hand, is controlled by the vote based on the vote to the dollar invested—one share of stock, one vote.

The Declaration of Independence states that all men are endowed by their Creator with certain unalienable rights; that among these are life, liberty and the pursuits of happiness; that, to secure these rights, governments are instituted among men, deriving their just powers from the consent of the governed.

Herein lies the true field of Government, and herein lies the explanation of control by the vote to the man.

But the object of the Industrial Corporation is not the guarding of the unalienable rights of man but the creation of wealth, and experience has shown that control vesting in the vote to the dollar is most suited to the end in view. How

self-evident this is, may be shown by a simple illustration. Suppose a Mr. Brown is asked to invest ten thousand dollars in a Corporation which is to manufacture bridges and he is told that Mr. Smith has invested one thousand dollars therein. Could Brown be induced to invest his ten thousand dollars if told that Smith with his one thousand invested would have just as much control over the Corporation's affairs as Brown with ten times as much at stake?

It would, of course, be impossible to secure uncoerced co-operation on any such basis.

But while the province of the Iudustrial Corporation is the creation of wealth and not the safeguarding of the unalienable rights of man, yet it frequently happens that, in the endeavor to create wealth, the Corporation (and the Individual as well for that matter) does jeopardize these unalienable rights and thereby finds itself in conflict with the Governments, whose function it is to prevent such encroachment.

One of the most important functions of Government is to safeguard the property rights of the Individual: refuse such safeguard and the entire structure of our Civilization falls to the ground.

Many years ago the Individual was constantly in fear of "that good old law (of the robber baron) that he will take who has the power and he will keep who can." Centuries of struggle resulted in the destruction of this idea that physical might makes right, but the Individual has still not been satisfied. By effort after effort he has endeavored, and is still endeavoring, to establish the corollary that neither does intellectual might make right, and that it is just as unfair to use superior intellect to dispossess him of his property as to do the same thing by means of superior physical strength, only it is far more difficult to see how, in this last case, to protect himself.

In all ages, a few men have been endowed with physical or mental strength, or both, much in excess of the average possessed by their fellows, but most men are alike in their desire for the good things of life and there has been, is and, no doubt, always will be a struggle in progress for their possession.

In this struggle, the only hope of the weak lies in the developing sense of justice of the community, or in the strength of numbers: but there is little strength in numbers without organization, and the danger in organization lies in the difficulty of controlling the leaders of the organization.

The determination on the part of the many to find adequate means of protection from spoliation at the hands of the few, whether through the exercise of superior physical strength, as in the past, or through the exercise of superior intellect, as at present, would seem to be the great primary economic force the working of which is the cause of the social unrest of to-day.

Principally, this pressure today shows itself in the form of laws aimed at various phases of corporate management and, because the efforts have not always been crowned with success, we hear much of Government Ownership of Industries.

This would seem to mean the threat that, if the ungifted masses cannot control the gifted few so as to secure the satisfactory distribution of the wealth created under such guidance, then they will use their superior numbers to take away altogether from the few any control over such production and distribution.

Socialism is a manifestation of this force; anarchism is another manifestation by a lower and more desperate element of society.

History shows that, since its beginning, this force has been at work. Fortunately, this country possesses a great middle class which can, in the end, be depended upon to select the prudent course, avoiding the pitfalls of selfishness on the one hand and of fanaticism on the other

What, then, should be its attitude in this situation?

The removal of the skilled industrial leader in favor of the demagogue, or even the statesman, as the director of wealth-producing aggregations of labor and capital certainly means great curtailment of total wealth creation, even possibly, to the extent that the more even distribution demanded might still mean a reduced amount to those objecting to the present methods of production.

The presence of wealth is an absolute prerequisite to the development of the individual above the level of the brute. Without wealth there could be no leisure from the constant struggle for mere animal eixstence.

With wealth comes the opportunity for cultivation of the higher nature, for development of all the faculties with which we are endowed.

Therefore, while the securing of protection to life and liberty are of vital importance, so also is the production of wealth, and it is of the utmost importance to a nation that its efforts in wealth creation shall be productive of the maximum possible result consistent with securing to the greatest number the ultimate benefits which the possession and use of this wealth should bring.

It is generally recognized, as instance our patent system, that, in order to encourage the production of wealth, it is necessary to permit the creator of new wealth to possess at least a goodly portion of that which he creates.

There is resistence, however, to any and all efforts tending to the mere transfer of wealth. And here it must be kept in mind that, by wealth is meant all that surplus of useful production above immediate necessities of supporting life which the industry and skill of man enable him to collect.

Evidently every worker who produces faster than he consumes is adding to the wealth of the community while all those who do not so produce are lowering its total wealth.

Also, evidently, the man who works or pretends to work without producing new wealth, enough at least for his own support, is merely a burden on the community whether he be a beggar or a man occupying a position for which there is no real need.

To illustrate: Suppose five men were cast away on an island and that four of them do various kinds of work to enable them to collect food, provide shelter, etc.; the fifth man merely accompanies one of the other men, but does no work because he is not there needed—he is just as much a burden on the little community as if he were confined to his bed.

As has already been stated, experience has shown that the industrial corporation is the mechanism that is best suited to the economic production of wealth.

Such being the case, it would seem to be the part of wisdom to study its defects and endeavor to remedy them and to discover the relations which it should sustain with the various forms of government, rather than to take up with methods known to be inherently unsatisfactory.

Certain criticisms of the industrial corporation are frequently heard, and may be stated as follows:

(1) The corporated mechanism lends itself readily to usurpation, by a few persons, of the power of wealth that should be exercised by the many.

(2) It offers a ready means whereby the majority can oppress and destroy the minority interests.

(3) Through manipulation of its securities and misrepresentations as to their real value, it offers the means, on a large scale, for those who are in power to use their superior knowledge to relieve the unwary of their wealth, thus enriching themselves at the expense of others instead of by the legitimate means of creating new wealth.

(4) It facilitates the production of monopoly and the utilization of this economic condition to extort usurious profits.

(5) It supplies the means through discrimination between customers to enrich some and to destroy others.

As to remedies proposed, there seem to be but three to choose from, viz:

1. Government ownership.
2. Anti-monopoly legislation.
3. Governmental regulation of industrial corporations.

Government Ownership.

As to government ownership and conduct of industries, one has but to study the character of the government afforded our various municipalities, spoils ridden as they are, to realize that this must be regarded as a last desperate venture to escape the intolerable after all other things have failed to protect the people from spoilation at their own hands, who are the stockholders of the corporations.

In general, under industrial corporation ownership and operation, the forces at work are—

1. Pressure from the public for cheaper and better service.
2. Pressure from the employes for higher wages—and as against these,
3. Pressure from the stockholder for larger dividends.

The only way to satisfy all parties is to secure more and more economical operation. This requires high executive capacity and demands competent subordinates throughout.

If, however, the added profits due to greater economics are, by law, diverted from the stockholder to some other source, then the incentive toward economy is destroyed.

Under government ownership, the forces at work are—

1. Pressure from the public for lower prices or better quality, or both.
2. Pressure from the employees for higher rates of remuneration.
3. Pressure from the politicians for jobs, not on the basis of capacity, but as spoils in return for political services to those in authority.

There is little attention paid to the cost of the service for the reason that, if the cost is greater than the earnings, the deficit is met from general (often direct) taxation instead of from taxation for the specific purpose of meeting that particular deficit and no one realizes that he is being taxed to meet that particular case of poor management.

The executive officer, upon whom this pressure is exerted, knowning that he must maintain, not his reputation for capacity, but his popularity, in order to retain office, soon learns that the easiest way for him is to lower prices, raise wages and furnish jobs, letting the added expense be buried in the added taxation.

As examples of this tendency may be cited the following:

The U. S. postal service is conducted at a loss, which is made up from the proceeds of customs and excise taxation.

The city of New York operates at a loss of over a million dollars a year a ferry between New York and Staten Island. These ferry boats actually have over double the number of employes per boat required by the various railroad ferries in New York harbor, and this increase in force has occurred since the city commenced to operate the boats which were formerly operated by the Staten Island Railway Co.

As an illustration of the result of government ownership of railways in an Aglo-Saxon community, may be offered the following extract from

"A memorandum relative to railroad organization, prepared at the request of the railroad commissioners of the Cape Government Railways, by Sir Thomas R. Price, formerly general manager of those railroads, and now general manager of the Central South African (i. e., Transvaal and Orange River) Railways, dated Johannesburg, February 22, 1907. 1907.

"The drawbacks in the management of the railroads in the Cape that call for removal arise from the extent to which, and the manner in which, the authority of Parliament is exercised. They are two-fold in their character, viz:

"(1) The practice of public authorities, influential persons, and others bent on securing concessions or other advantages which the general manager has either refused in the conscientious exercise of his functions, or it not likely to grant, making representation to the commissioner (as the ministerial head of the government), supplemental by such pressure, political influence, or other means as are considered perfectly legitimate in their way, and are best calculated to attain the end applicants have in view.

"(Many members of Parliament act similarly in the interests of the districts, constituents, or railroad employes in whom they happen to be interested. It is by no means unknown for the requests in both classes of cases to coincide somewhat with a critical division in Parliament—present or in prospect—or otherwise something has occurred which is regarded as irritating to the public or embarrassing to the government, and the desire to minimize the effect by some conciliatory act is not unnatural.)

"(2) The extent to which the fictitious, and often transitory, importance which a community or district manages to acquire obscures (under the guise of the Colony's welfare) the consideration of the railroad and general interests of the Colony as a whole.

"I do not regard it as open to doubt that the Colony as a whole has suffered severely in consequence, in inland portions of the Colony particularly so; and that the need for a remedy is pressing if the railroads are to be conducted as a business concern of the Colony.

"The necessity for the railroads and their administration being removed from such an atmosphere, and treated as a most valuable means of benefiting the Colony as a whole, while not neglecting the interests of a district (but not subordinating the welfare of the whole Colony thereto), is pressing. That there should be an authority to refer to in case of real necessity, where the decision of action of the general manager is not regarded as being in the public interests, is also clear. But it is equally manifest that the commissioner or the government of the day, with political or party consideration always in view, is not the proper court of reference.

"There can be little doubt that, in the Cape Colony, political consideration have influenced the adoption of new lines and their construction—many, if not most of them, of an unprofitable character—without sufficient inquiry or information, often with scanty particulars, and possibly contrary to the advice of the officer afterwards entrusted with the construction and working of the line.

"A material change is imperatively necessary in this respect, if only to insure the solvency of the Colony."

The best example of anti-monopoly legislation is the Sherman Anti-Trust Law passed by congress in 1890, Section I of which reads in part, as follows:

"Every contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade or commerce among the several states, or with foreign nations, is hereby declared to be illegal."

(The courts have just interpreted restraint of trade to include even cases where trade might be restrained but, at present, is not, and this interpretation, if acted upon, as it must be, by the executive, means, not the regulation, but the strangulation of co-operative industry.)

The object of the Sherman Anti-Trust Law was to secure the protection of the public from extortion on the part of industrial concerns by preventing the elimination of competion in business through the creation of monopolies, leav-

ing to competition the automatic adjustment of prices to a satisfactory level.

In this connection, it is interesting to note that the action of the Standard Oil Company in relentlessly carrying competition to the bitter end is responsible for the efforts now being made to destroy that company; evidently it was not the intent of the framers of this law that competition (which it is the object of the law to encourage) should be carried to extremes, but that it should be conducted entirely in a lady-like and inoffensive manner.

The third plan, the regulation of corporate activities by the governments, is, in reality, an attempt to work out the proper relations that should exist between federal, state and municipal co-operative mechanisms or corporations on the other, for the good of the great number of people, whose working tools all of these mechanisms are.

It has in view the control of the objectionable features of corporate activities while encouraging co-operation and unobjectionable trade agreements, thus substituting the reign of industrial law and order for war.

It must be recognized that the successful operation of any such system of regulation is dependent upon the honesty, fairness, knowledge and wisdom of the regulating body as well as upon the character of the laws under which the regulation is executed, and upon the ability of the courts to promptly and impartially enforce the laws.

In the framing of laws, the legislator is supposed to consider all sides of the question, but not being infallible, if one of the parties at interest, instead of aiding in the drawing up of a just and effective law, merely as an obstruction, it becomes difficult, especially in dealing with complicated industrial subjects, to avoid one-sided laws, or those containing very objectionable features.

Also, if the Regulating Commissions, or Courts, are composed of men actuated solely by the desire for political preferment, or by still worse motives, or if they are ignorant of the subjects before them for treatment and do not sufficiently inform themselves, or if they are over-burdened with cases requiring their attention, satisfactory results can hardly be expected. Special fitness for the work and absolute freedom from political pressure should always be possessed by the incumbents of such positions, for they are really Arbitrators between different groups of the People (some, stockholders of the Corporations, others not) and the object of their being is to aid in protecting the Rights and in increasing the Wealth of all.

Publicity as to Corporate Affairs, it would seem, could readily be secured insofar as necessary to protect investors and would-be investors from fraud, and there seems little opposition to such an arrangement. Fair progress in this direction is being made.

The protection of Minority against Majority interests rests very properly with the Courts and can be aided if Justice can be rendered more speedy and less costly than at present; also, some regulation of the form of Corporate Charters might be of value.

Discrimination as between customers becomes important only as Corporations increase in size. For illustration:

Because it injures no one, there can be no reasonable objection if farmer Jones sells to his friend Brown a bushel of potatoes at half the price he charges other customers.

It is recorded that a great Merchant once had a Clerk who had served him long and faithfully and who, having saved a few thousand dollars, thought he would like to start a little store of his own. He bought his modest stock of the great Merchant, who promptly thereafter cut the price on these articles on his own counter to below the wholesale price paid him by his former Clerk and so destroyed him. This is not pleasant reading, but it was an isolated case and did not greatly affect the interests of the general community.

We know, however, that a freight rate may be so arranged as either to build up or to destroy an entire business community. This becomes decidedly of importance solely because of the magnitude of its results, for discrimination is present in all three of these cases cited. Regulation in this respect is being successfully carried on.

Usurpation of the power of Wealth is a serious matter, even as usurpation of Civic Authority is a dangerous thing for the community. The two things which have made it materially possible are:

(1) The ability of a corporation to own and vote the stock of another corporation;

(2) The issuance of bonds, having no voting power, against stock held as collateral, the voting power of the stock remaining in one set of hands while the money is supplied by a second set, and while still a third set are affected by the stock vote.

For example: John Smith has one dollar. He buys a majority of the stock of Company "A", capital $1,000,000, and issues $500,000 of collateral trust bonds to pay for the stock. He uses the $1,000,000 of money in the treasury of Company "A" to buy control of Company "B", capital $2,000,000, and so on indefinitely. Here John Smith, not with the consent of the other stockholders, has usurped the power to dictate the use of $2,000,000 of other people's money and yet has none himself at stake, nor can he be dislodged from this position by the real owners.

It is paralleled, politically, by the history of the Great Napoleon.

In 1799 he found France governed by a method so weak that he was enabled, through the army, to seize the reins of government and secure to himself autocratic power.

He used the wealth and army of France to conquer other countries and then, seizing the treasury and government of the conquered country, was able to use that added force to aid him in further conquest until nearly all of Continental Europe was at his feet.

Our Government is so designed as to offer very little opportunity for such usurpation, and the design of our Industrial Corporations probably needs radical improvement along these lines, bearing in mind that there is no objection to placing power in the hands of a competent man provided he can hold it only at the will of those affected, but that it is objectionable to have it possible for him to seize power and be able to hold it subject to his own will only.

That the Corporate form of industrial activity tends to create monopoly, is unquestionably true. Also, it is unquestionably true that, with monopoly, the price of the product must either be subject to arbitrary control of exorbitant prices will ultimately be demanded.

Competition versus Regulation.

The proposition to arbitrarily regulate Industrial Activities on the one hand, and the Sherman Anti-Trust Law proposing, by eliminating Monopoly, to let Competition regulate, on the other, presents, therefore, the great question whether Monopoly or Competition is the economic condition best fitted to secure to the greatest number the greatest good from the efforts to create wealth.

We cannot have both at the same time. Which shall it be? What are the arguments for and against?

Against Monopoly are usually cited these objections:

1. There is no control over the price of the product and the purchaser is, consequently, subject to extortion.

2. Monopoly, lacking the spur of competition, tends soon to bring about inefficiency on the part of the management and employees, this leading to lack of economy and consequent high cost of production.

3. Monopoly also deadens the spirit of progress and prevents the adoption of superior methods and mechanisms.

In a word, it is claimed that, due to the lack of the constant pressure of competition, Monopoly tends to produce high prices and poor service and is, consequently, not consistent with the economical production of wealth.

In favor of Monopoly are usually cited:

1. The saving in Capital due to avoidance of duplication of plants.

2. Greater economy of production due to large output from one plant as against small output from each of several plants.

3. Stability of Industrial Affairs as against the constant strife of Competition; for Competition is merely Industrial War.

In addition to these arguments there is frequently heard expressed the fear of the power of concentrated wealth if Monopoly be permitted.

The ideal condition would, of course, be that which combined all the good features of both the Competitive and the Monopolistic state and eliminated their bad features. This would mean Regulated Monopoly, the regulation probably controlling:

1. The quality of the product.
2. The selling price.
3. Publicity as to fiscal affairs.
4. Discrimination between customers.

And, finally, and upon the accomplishment of which the success of regulation will turn.

5. Protection of the Corporation from the Community to the extent of permitting it to secure a proper profit upon its investment and to secure a reasonable proportion of the benefits accruing from skillful operation, thus leaving the Stockholder in his present position as the force constantly pressing for greater efficiency and consequent profits.

The tendency of Industrial sentiment in this country today is strongly toward combination, while the tendency of Political sentiment is strongly in the other direction.

It is probably reasonably correct to say that Industrial sentiment means that of the Producer, while Political sentiment means that of the Consumer; at least, this renders intelligible these conflicting views.

The elimination of Competition goes through several phases and probably will not be complete in any country for many generations, if at all.

To illustrate:

The simplest form of Competition is between Industries of the same kind—as manufacturers of pig iron. Let us suppose these to have endeavored to eliminate competition by consolidation.

They would still be confronted with the second class of competition, that between producers of the same class. Prior to the formation of the United States Steel Corporation, one group of persons owned ore mines, another owned vessels to transport the ore, still another group owned railroads also engaged in transportation; the owners of steel works formed another group and the bridge builders still another.

The raw materials in a steel bridge cost a certain amount and the finished bridge sold for a certain greater amount, the difference representing the total cost of production plus a total profit. Naturally, each party to this transaction desired the whole profit, or, barring that, as large a slice as possible.

The United States Steel Corporation ended this Armageddon of industrial warfare by buying the mines, the boats, some of the railroads, the steel mills and the bridge works. Thereafter, the part of the profit due each branch of the industry ceased to have more than an academic interest, and all were left free to attend to the business of reducing costs and increasing output.

So well did they succeed that, during the recent tariff agitation, the United States Steel Corporation took the ground that, as they could produce steel several dollars a ton cheaper than their competitors, a tariff reduction, by destroying the latter, would give them all the business and be a benefit.

But, assuming that all the various groups of associated industries should destroy this class of competition by following the example of the United States Steel Corporation, there would still remain two other classes.

Suppose there was but one Steel Company, one Sugar Company, one Tobacco Company, one Lumber Company, one Railway Company, and so on, they would still have to compete for capital and labor.

If, to avoid this competition, all Industry, including banking, was handled as one huge Corporation, then there would still remain the competition between the stockholder demanding a higher rate of return on his investment and the employee demanding a higher rate of remuneration for his labor, although this would, no doubt, be softened by the fact that most employees would also be stockholders.

As regards the fear that such huge concentration of Industrial Control would lead to a plutocratic form of government, it would seem that this is merely the spectre used by the demagogue for his own ends.

To take the extreme case, where all industry is conducted under the direction of one huge Corporation, would it not be impossible to manipulate the shares of such a Corporation in the way the shares of smaller corporations are manipulated today? Would it not also destroy the power to pyramid control, which power is so much abused today? Would it not greatly reduce the opportunity to acquire huge fortunes by exploiting corporate securities? The Stockholders would be, principally, the people of the United States—would it be possible for them to oppress themselves?

Further, there is another argument in favor of intelligent regulation of huge corporations instead of attempting, as per the Sherman Law, to destroy Monopoly.

It lies in the opportunity for vast economic improvement which might result from more intelligent conduct of such affairs from the national point of view.

The Industrial Corporations of this country are today in much the same condition economically that France, Germany and other countries of Europe were politically during the Middle Ages, when each petty noble attempted to maintain his independence, and wasted his energies in petty strife with his neighbors, instead of forming a unit in a great and powerful nation.

The Industrial Corporations, having no great central authority to direct their general policy, cannot co-ordinate their activities, have no unity of purpose and exhaust much of their energy and strength in destructive competition and duplication of plant and production instead of bending their energies toward producing the maximum of wealth for the energy available. To illustrate:

From 1894 to 1898 there was great distress throughout the United States. The farmer suffered because of extremely low prices for grains and stock. The steel manufacturers and workers suffered because of low prices and little demand for steel. The coal miners suffered in like manner from a reduced demand for coal. And so on through all classes of industry.

There was ample grain, ample stock, ample iron ore and other ore, ample coal in the mines, ample lumber in the forests, to furnish abundant food, clothing, fuel and shelter for all, and there were thousands and thousands of men willing and anxious to work—and yet there were thousands almost at the point of death from starvation, lack of fuel to keep them warm, lack of clothing and lack of all other necessaries of life—why?

Because the farms produced more food than could be sold at a profit; the mines produced too much coal; the miller too much flour, and there were too many men ready and willing to work.

The miner had no work and no money because the baker bought no coal, and the baker bought no coal since, because the miner bought no bread, he had no money to buy coal!

Too much raw materials; too many laborers; too much excellent machinery—they all united to produce, not plenty, but poverty. Was ever anything more tragically ridiculous?

Imagine several men cast away upon a deserted island and imagine their telling a story that, because it was so easy to produce food, fuel, shelter, clothing, etc., they nearly perished!

What they would naturally do, under such easy circumstances, would be to reduce the time spent on these employments to just sufficient for their needs and employ the leisure so gained to produce other desirable things.

The people of America do not do this because Industrial Concentration has not yet progressed far enough to make possible the co-operation necessary to the securing of such results.

America is not the only nation that is, today, struggling with this great economic problem. Germany, England, Japan, all are trying to solve it in such way as to make them the Industrial Dictators of the World.

With all of these we are in sharp competition in many fields today.

Germany and Japan are directed by powerful Monarchic influences. American legislation is powerfully influenced by a Written Constitution, very difficult to alter, and created while the economic development of the world was in its cradle. English legislation is checked by an hereditary House of Peers, who largely represent the landed interests of the country.

The most menacing figure today, looming dark against the sky of American Prosperity, is the Demagogue.

Ever on the alert to seize upon the ignorant fears and prejudices of the masses and to blow up a storm which shall waft the craft of his own personal interest toward the port of popular favor, he cares nothing if the ocean of industry is strewn with the wrecks of those who under gentler skies might have sailed on in safety and content. So far have his machinations carried the unthinking that it is a question if today the Personal Liberty of the Individual is not in as much danger from the tyranny of the masses as, in Colonial days, it was from that of the Sovereign.

If the great prize is, through such means, snatched from the American Nation, the People, who have the power to elect good and wise men to the positions of Public trust but do not, and the Leaders of Industry, who have it in their power to teach the People as to the real basis of industrial prosperity but do not, will have but themselves to blame.

The Maintenance of Way Department.

Adzing Treated Ties.

Editor, Railway Engineering:

Concerning the adzing of creosoted and other treated ties, in the writer's opinion there is no material difference as to the necessity of adzing ties whether treated or not inasmuch that in the absence of tie plates and even where they are not strong enough to resist the load, especially on the inside of curves, thereby causing rails to cant outward, which is what creates the necessity for adzing of ties. Even on tangents the rail is inclined to cant outward under the strain necessitating the adzing of ties in order to place rails in proper position when relaying, replacing, etc.

We also find it is frequently the case that ties are bowed upward, necessitating adzing of that portion of tie that rails rest upon, in order to get a full and proper bearing of the base of the rail upon the tie or upon the tie plate as the case may be.

We favor the adzing of ties a little deeper on the inside of the base of the rail in order to cause rail to cant slightly inward, experience having taught us that rails incline to wear more next to flange than otherwise, so that by canting them as above described, it has a tendency to give the ball of the rail an equal bearing the full width of the ball, which, it stands to reason, is more proper than otherwise.

Thanking you kindly for having given me the benefit of airing my views and obtaining the benefit of others, with best wishes and highest regards, I remain,

Very truly yours,

Wisconsin. Roadmaster.

Cross Ties in the South.

Editor, Railway Engineering:

The cross-tie question in North and South Carolina never having been a serious one, as in some of the more thickly populated states, no roads in this vicinity, street railways excepted, have ever treated any ties, and, as my maintenance work has all been in this section, I have had no experience with creosoted ties.

I do not confine adzing to any season, but whenever rails commence turning on curves the rails are taken up and ties adzed off to give the rail a smooth bearing and bring it back to proper position.

We use 7-in. x 9-in. x 8-ft. 6-in. ties made from white oak, post oak, chestnut oak, chestnut and long leaf yellow pine.

Chestnut ties are used in straight lines exclusively, as they are too soft to maintain gage in curves.

Long Leaf Pine ties are used on straight lines and curves up to 6 degrees, without tie plates. From 6 degrees to 10 degrees, we use tie plates on every third tie and in curves over 10 degrees, on every second tie.

The Oak ties are used same as the Long Leaf Pine.

I find the oak ties, cut from timber at an elevation of over 1,200 feet will only last six or seven years. Those cut from an elevation of 600 to 1,200 feet will last from 8 to 9 years. While the low country swamp white and post oak ties will last from 10 to 12 years.

The prices for these ties vary from 30 cents for first class Chestnut to 50 cents for first class Oak.

Yours truly,

South Carolina. Roadmaster.

Creosoted Ties.

Editor Railway Engineering:

In reference to adzing creosoted and other treated ties, we adze all ties when necessary to make a level surface or full bearing under rail. We use all creosoted hard wood ties on our line.

Yours truly,

Michigan. Roadmaster.

Winter Maintenance.

Editor Railway Engineering:

With reference to the subject of winter maintenance of track, I may say, that in this part of the country we have to resort to various methods, as our winters are very changeable, in respect to thawing and freezing. In the first place we endeavor, in the fall to have our ditches as clean as possible, as our road is, generally speaking, a mud road. Good Ballast is hard to get. After frost sets in and about January

10th track begins to heave. We shim between rail and tie. If shims are required no thicker than ¾-inch, we draw spikes up about one inch and insert shims angle ways between spikes. Except on curves, in which case we bore all shims over ½-inch thick. When making and preparing shims, we only bore one end of shims. Then when putting in shims, we pull both spikes out of tie, plug both holes, place shim with hole already bored, so spike will go into old hole, make a pencil mark on rail on other side to indicate position of old plugged hole and then bore directly over old hole, this enables track man to have both spikes in old plugged hole, which prevents tie from being cut up too much with spike holes.

When frost is coming out in the spring, we make it a rule to interfere as little as possible with the tie bed; in very soft places we cut up old crossing planks (or any old material in plank form) about 3 feet long, and place those pieces under rail between ties first and drive thin shims between these pieces and rail to give firm bearing. I find this a better plan than placing ground shims under end of tie. When road bed is not dry enough to tamp in early summer, where low spots exist, I find the best plan is to raise track with jack, about ½-inch higher than surface required and throw in dry material without tamping the same and let track down on this; by using good judgment in the lift given, the first passing train will depress it to its proper surface.

Yours truly,

Canada. Roadmaster.

Adzing Creosoted Ties.

Editor Railway Engineering:

In regard to adzing creosoted and other treated ties, I have had no experience with them. I believe if the creosoted or treated ties were injected or penetrated with a proper amount of creosote, a moderate amount of adzing would have little effect upon the life of the tie.

We use in this locality Yellow Pine ties on our Main Branch. On other branches we use Yellow Pine, White Oak, Red Oak and Cedar ties. Cedar ties are type-leaded. Our heaviest power is operated over tracks with these classes of ties; tracks are laid with 70 lb. and 80 lb. rail; total weight of heaviest engine in working order approximately 180 tons.

Ties are adzed to roll in rail where it has been rolled out by traffic on curves and tangents. Adzing seldom exceeds ½-inch.

Yours truly,

New York. Division Engineer.

Adzing Treated Ties.

Editor Railway Engineering:

Relative to the adzing of creosoted and other treated ties, I beg to advise you that we have only been using zinc ties since 1907 and have adzed them at different places where needed. We have experienced no trouble so far due to adzing.

Yours truly,

Indiana. Supervisor.

Treated Ties.

Editor Railway Engineering:

In regard to adzing creosoted ties, I often find it necessary to adze treated ties in making rail changes as it is a matter of importance that rails be laid to an even plane and that the base of the rail has a full bearing on tie. I have not noticed any bad effect on treated ties by adzing as we use a good large tieplate and that part that has been exposed by adzing is usually covered by the tieplate.

We have been using a good many treated pine ties on my Division the last 3 years but I think we will get all oak ties for this season's renewals.

Again referring to the adzing of ties: I will add that all ties, no matter whether treated or not, should be adzed so as to give rail full bearing regardless of kind of tie or whether making rail changes or making tie renewals.

Yours truly,

Iowa. Roadmaster.

Track Maintenance.

Editor Railway Engineering:—

In regard to track maintainance, our line is laid with 52 lb. steel, 18 ties per rail on dirt road bed. We have 14 regular trains per day in southern California. We have much rain during the winter season. As is the case with all dirt track in wet weather we have much trouble with track knocking out of line and surface. The first essential in maintainance of dirt track is drainage and this feature I keep in mind at all times, draining track at any and all times and preparing for the wet season. When the surface becomes too bad in wet weather I have the men make shims out of old ties and shim under the ties, draining the shims as well as we can. These shims are removed in the spring as soon as the weather becomes settled, and the track again curfaced on dirt. We use what decomposed granite we can get, dressing it rounding in the center same as dirt track. Our ties are mostly Red Wood. They last 12 and 15 years under our traffic.

Yours truly,

California. Roadmaster.

Creosoted Ties.

Editor Railway Engineering:—

With reference to the method of placing creosoted, or other treated ties, in track, I would say that my experience with creosoted ties, or other treated ties is rather limited. My first experience being last year. I received and put in track 22,500 creosoted ties, black and red oak, principally all hewed ties. I found that some of those ties, after one end was spiked, that the other end would not fit the rail and that it was necessary, in such cases to do sufficient adzing to get a full bearing for the rail base for the entire width of face of the tie. I think any tie should have a full bearing for entire width of its face under each rail, otherwise the tie will not be expected to give good results in service, as if the condition of the tie is such that it will have a full bearing under one rail, and is so spiked, and that the other end takes a bearing under the opposite rail only on one edge, that tie will be inclined to roll, a tie in that condition will not afford good results.

I use oak and chestnut ties on main track and oak ties in curves of all tracks; use some cedar ties on side tracks and in some Branch lines where traffic is light; use tie plates on oak ties in curves only; ties spaced 20-in. centres, also use tie plates on chestnut and cedar ties. I adze all ties necessary to get a full bearing the entire width of the face of tie under each rail.

I think more care should be given to inspection of ties before being treated. All ties should have paralled faces; worthless or decayed ties, or ties with bark on, should not be treated, as the creosoting, I understand in some instances, only penetrates one-half inch. The value of the tie, is to some extent lessened, when adzing has to be resorted to, where the faces are found to be not parallel.

Your truly,

Canada. Roadmaster.

RAILWAY ENGINEERING
AND MAINTENANCE OF WAY.
BRIDGES—BUILDINGS—CONTRACTING—SIGNALING—TRACK

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Railroad Construction.

The railroad tie is an important factor in the cost of new construction and maintenance of track and leads railroad men to an active consideration of legislation that affects forest preservation. In fact, maintenance of way men, particularly roadmasters, should influence their representatives in congress and keep the question alive. We quote a few paragraphs here from a report by Willis L. Moore, chief of the United States Weather Bureau, on "The Influence of Forests on Climate and on Floods":

"Conservation of national resources is national economy, just as conservation of private resources is personal economy. But whether personal economy is beneficial or harmful to the individual and his children depends upon the extent and nature of that economy; and the same thing is equally true of a nation. Conservation that prevents the practical use of individual or national resources is like unto the economy of the timid servant that hid his master's talent in the earth, and in large measure deserves the same condemnation.

"There should be neither wasteful use of resources nor that greatest waste of all, total disuse of them, but that economical use which in the end will have yielded the greatest good to the greatest number.

"Preservation of the forests, cutting wisely, but never more than they reproduce, enables us to draw from a perpetual supply a certain quantity of material for buildings, for furniture, and for fuel. But of course that forested land yields not a handful of wheat nor of corn and makes but a wretched substitute for the pasture upon which to feed milch cows and beef cattle. These conflicting interests, the pleading of the poor man's children for bread and meat and the cry of the country for the lumber that only a woodland can furnish would, if there were no other interests to modify the result, somewhere find an inevitable balance. But just as the body is more important than its raiment, so, too, is its food more important than its shelter; and therefore in every country the general tendency, with growth of population, is to convert forest lands into cultivated fields, and this tendency should not be discouraged unless it can be shown that deforestation has augmented droughts and floods, and I believe that it cannot be so shown; I believe that forests should be preserved for themselves alone, or not at all."

In conclusion we may best emphasize the position that railroad men should take by the following notation: The animal lives by seasons as a rule, preparing the food and shelter for the winter during the summer; the man prepares or should prepare for old age in his youth, and the government should preserve our forests for generations. Man and government may therefore oppose one another on account of the difference in periods of time. This matter may not be discussed here, but every railroad man should form his own conclusions.

The Signal Department.

This month's instalment of our series of railway signal standards illustrates the methods used on two roads. These are grouped together by way of contrast and for purposes of comparison with the Rock Island standards presented last month. Both of the roads at present under consideration use lower quadrant, two position signals, being in this respect perhaps somewhat old fashioned. Consideration should, however, be given to the fact that the signal practice on both is comparatively long established, and whether or not it is advisable to change the signal indications radically on such roads, unless done throughout, is an open question.

The standards of the N. Y., O. & W. show that much care has been exercised in their development. The details are thoroughly worked out, one of the most interesting of these being the concrete battery box. This appears to be a very satisfactory and easily constructed device.

It would be interesting to know, however, how trains can make favorable meeting points on single track with the arrangement of overlaps shown, unless the train first to arrive at a station is compelled by rule to take the siding. With a train occupying the main track at a station, any other train would be held at one of the intermediate staggered signals. Another novel feature is the method of staggering signals outside of the station switches. This is a practice which has a number of things to recommend it, one being the abolition of the possibility of two opposing trains coming within a distance of each other equal to the thickness of the signal, as when signals are placed opposite each other.

Mr. Harland and the other officials of the road are to be congratulated on having sufficient courage to insist, in spite of the expense, on providing distant signals for all home signals on single track and on the use of neutral circuits to control them.

The South Side Rapid Transit Co., whose standards are also shown this month, operates an elevated railroad in Chicago on which the trains are propelled by electricity. Part of its line is equipped with three main tracks, and it is on the middle track, used for express service, that automatic block signals are installed. No overlap is used, and none is necessary, as the track in question carries traffic in one direction only: that is, all trains on this track move toward the city in the morning and from the city in the evening. The road is thoroughly equipped with interlocking, all plants in continuous use being of the electro-pneumatic type. There are also numerous station and curve signals operated automatically by solenoids.

Road Appliances*

The question I have the honor to deal with for the Congress, viz., the elimination of speed restrictions (a) in connection with swing bridges and (b) in connection with junctions is important, from the fact that every permanent condition necessitating a reduction of speed is a constant factor detrimentally influencing the earning capacity of a line, and in a measure tending to increase the cost of working and maintenance, and further, having regard to the increasing demands of the public for more expeditious travel, and also to the strenuous competition between companies to secure the utmost proportion of long distance traffic, it is essential that all speed restrictions should be eliminated as far as commercially possible. To such an extent has the demand for faster travel been met by the railway companies, that in many cases it would appear that the limit of further facilities under existing conditions, has been reached.

If the almost paramount consideration is to be the further shortening of the time occupied on the journey by travelling at still higher average speeds, then, having due regard to safety and comfort, not only will it become necessary to consider the question of improvements of junctions, but in addition that of improving curves in many parts of the main lines, so as to reduce the limitation of speed to a minimum.

With the tendency on the part of the travelling public to press for still faster trains, and the willingness of the railway companies to meet, as far as reasonably possible, all the demands of their customers, the question submitted to me becomes of special importance. It will be apparent that, where competition is keen, the number of speed limitations, lengthening as they must do the time occupied on the journey, may be the factor, all other things being equal, governing the route by which passengers will travel.

Much has been done, and is still being done, in the improvement of curves on the running lines, and at the junctions and their immediate approaches, with the result that it has become possible to considerably increase the average speed of trains, with no real diminution of comfort. In cases where the traffic is dense, "flying" or "burrowing" junctions have been constructed to avoid cross working of the "Up" and "Down" lines, with the consequent blocking and delays, thus giving increased facilities for traffic passing through such junctions. By reason of the additional freedom obtained, the speed of trains when approaching these junctions can be longer maintained, and thus a more regular average speed is obtained and considerable benefit derived. Much, however, still remains to be done throughout the United Kingdom, in respect to the improvement of junctions for fast speeds.

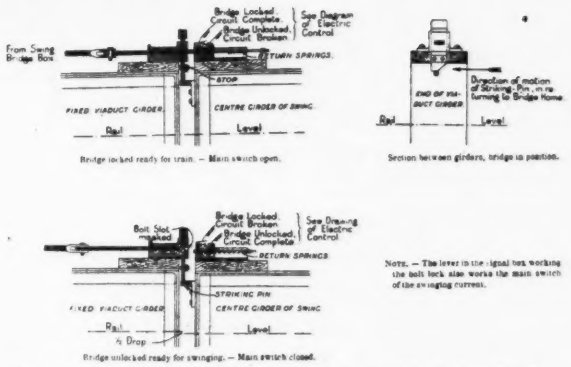

Bridge Locked. Circuit Complete.
Bridge Unlocked. Circuit Broken.
See Diagram of Electric Control
From Swing Bridge Box
RETURN SPRINGS.
STOP.
FIXED VIADUCT GIRDER.
CENTRE GIRDER OF SWING.
Rail
Level
Bridge locked ready for train. — Main switch open.
Direction of motion of Striking Pin in returning to Bridge Home.
END OF VIADUCT GIRDER
Section between girders, bridge in position.
Bolt Slot exposed
Bridge Locked. Circuit Broken.
Bridge Unlocked. Circuit Complete.
STRIKING PIN
½ Drop
Bridge unlocked ready for swinging. — Main switch closed.
Note. — The lever in the signal box working the bolt lock also works the main switch of the swinging current.

Fig. 1. Great Eastern Railway—Carlton Colville Swing Bridge.

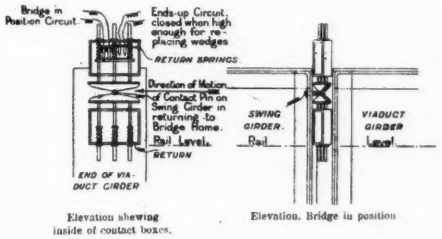
The restriction of the speed of trains owing to the presence of swing bridges, is comparatively of little moment in this country, for the number of such bridges on important passenger lines is very few in proportion to the mileage. It will be seen from the table attached, giving details of the replies sent in answer to the questions relating to swing bridges, that there are about 49 opening bridges over which passenger trains run, being approximately one bridge per 470 miles of route. There are, I believe, a few more bridges on some of the smaller lines not set out in the table, but the absence of the particulars of these bridges, does not in any material degree affect the question.

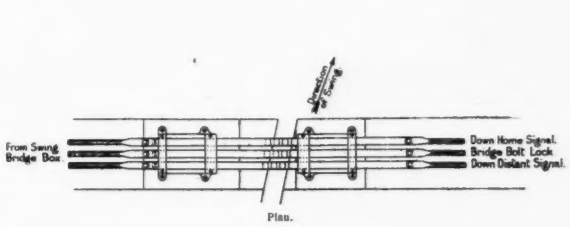
With few exceptions, swing bridges are nearly all situated on more or less unimportant lines, and taking this and their limited number into consideration, it is obvious that swing bridges, as affecting the question of speed limitations, may, for all practical purposes, be considered a negligible quantity.

I have, however, thought it well, with the view of perhaps lending to the completeness of the subject, to give the particulars set out in the table as to the location, and other general information in connection with the various bridges. As the question under consideration deals entirely with the elimination of speed restrictions consequent upon swing bridges, and as it will be seen that these bridges in the United Kingdom have but little real effect on the speed worked on the railways, I do not propose to deal with the matter further than by a few general observations.

In nearly every case where a reduction of speed is called

*From Bulletin of the International Railway Congress.


Bridge in Position Circuit.
Ends-up Circuit, closed when high enough for replacing wedges
RETURN SPRINGS.
Direction of Motion of Contact Pin on Swing Girder in returning to Bridge Home.
Rail Levels.
RETURN
END OF VIADUCT GIRDER
SWING GIRDER.
VIADUCT GIRDER
Rail
Level
Elevation shewing inside of contact boxes.
Elevation. Bridge in position



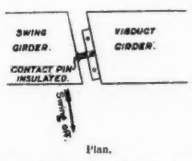


Fig. 2. — Bridge position detector (electrical).

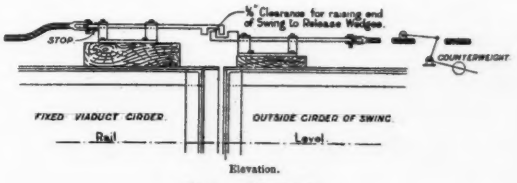


Fig. 3. — Disengagers.

Figs. 2 & 3. Great Eastern Railway—Carlton-Colville Swing Bridge.

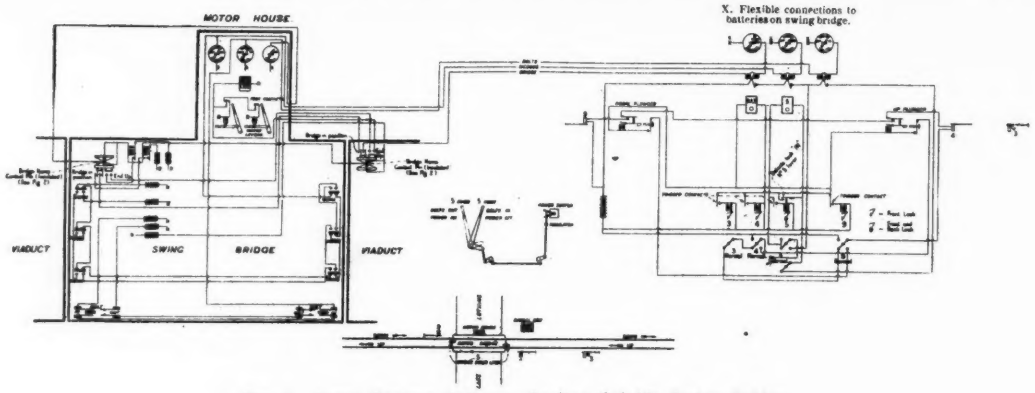


Fig. 4. Great Eastern Railway—Carlton Colville Swing Bridge.

for in passing over these bridges, it is due to either (a) sharp curves in close proximity to the approaches to the bridge, or (b) the limiting of speed necessary for exchanging the tablet or staff for single line working, or (c) a slack to pick up the Pilotman, when the line, though single over the bridge, is double on either side.

In the cases such as (a), the improvement of the approaches would enable the restrictions to be removed, the swing bridge being quite a secondary element in the case. In instances such as (b), the bridge only very indirectly affects the question of speed, as equal reductions must take place at all points of exchange of tablet or staff on a single line.

By arranging to have a tablet station at the bridge, the delay caused is more than it would be if the bridge did not exist, the one slack serving a double purpose.

In the case of (c), the fact of the bridge not being constructed with a capacity equal to that of the approach lines, brings about the necessity for speed restrictions, which can only be eliminated by incurring the expense of making the bridge to carry two lines of way.

Where the waterway traffic is of sufficient importance, the time occupied in opening and closing a bridge is of moment, and in such cases, power is generally used for working the bridge.

When hand power only is provided, the length of time occupied is not a material matter, having regard, in such cases, to the comparatively limited number of times the bridges are, as a rule, opened. It is conceivable, however, that the traffic on the waterways may change and become more important, maying the time occupied in operating the bridge worthy of serious consideration, not as directly affecting speed restrictions, but in respect to the curtailment of the amount of traffic passing over the railway.

The time occupied in the passage of vessels through the bridge opening is really the prime factor in delay at swing bridges, more especially where the use of the waterway is at all frequent.

It appears to me that if the altered conditions suggested should arise, and even in some cases under present conditions, that the most approved appliances should be provided for working vessels through the bridge, to obviate as far as possible, all unnecessary loss of time. The provision of any such appliances has been generally neglected, so far as the bridge owners are concerned; they having contented themselves with such works as were deemed necessary for the protection of the structure, and having provided little or nothing to assist the passage of vessels through the bridge.

In cases where power is used for working the bridges, it might, with great advantage, be extended for such purpose.

The general arrangements of locking and other appliances in connection with some of the bridges described in the table, are shown in Figures 1 to 18, and Figure 27 is a diagram of axle loads of the heaviest engines working over the bridges.

There are cases where the bridges are kept normally open for the waterway traffic, the rail traffic taking a secondary

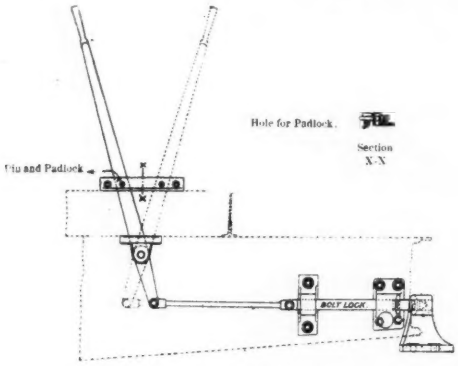


Fig. 5. — Hand lever bolt.

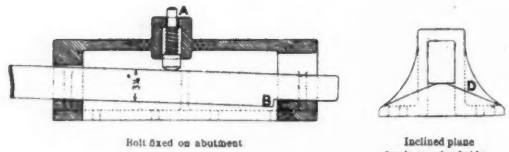


Fig. 6. — Locking bolt.

Figs. 5 & 6. London & North Western Railway—Oxford Swing Bridge.

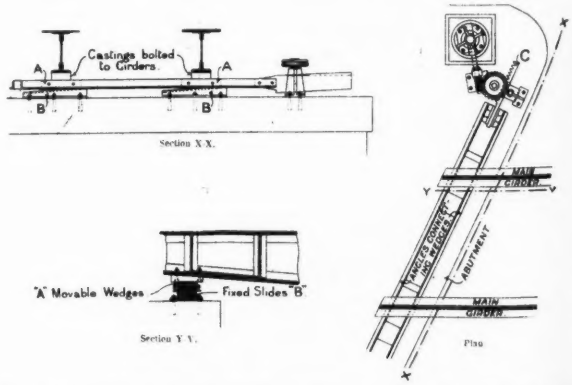


Fig. 7. London & North Western Railway—Oxford Swing Bridge.

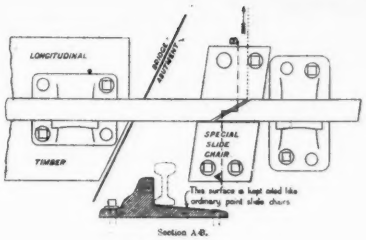


Fig. 8. — Rail joint.

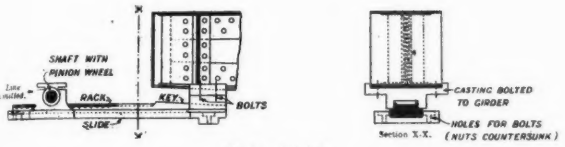


Fig. 9. — Slide locks.

Figs. 8 & 9. London & North Western Railway—Sankey Swing Bridge.

place, being much less frequent than the water traffic. I would mention the particular case of the Breydon Viaduct, on the Midland and Great Northern Joint Line, which may be of interest. It is worked as follows, so far as the special signaling for the river traffic is concerned.

A high mast is erected on the bridge. When one red ball is run up, the bridge is about to be closed against the water traffic, for a train to pass. Two red balls run up, 4 ft. apart vertically, indicate a breakdown, or other reason, necessitating a longer delay than usual in reopening for water traffic. The balls are kept up until the bridge is again open for water traffic. The mast, without any red ball at all, shows that the bridge is open for vessels to pass through. At night time, red lamps on the turret replace the balls, and when the bridge is open for river traffic, a white light is shown. To assist in the steering of vessels through the two opening spans at night, a green light is fixed at each end of the center dolphin, and a white light at each end of each of the two side dolphins.

The following short descriptions of the working of the Swale bridge on the South Eastern & Chatham Railway, the Clachnaharry Bridge on the Highland Railway, and Carlton Colville bridge on the Great Eastern Railway may be of interest.

Details of the Swale bridge are given on Figures 11 to 16.

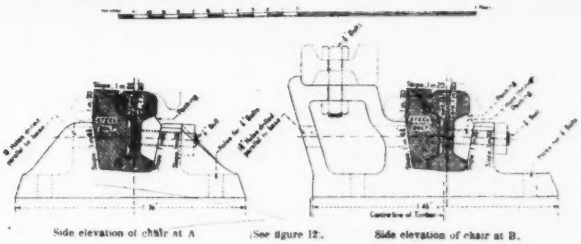


Fig. 13. South Eastern & Chatham Railway—Swale Bridge.

The bridge is mechanically bolted at both ends from the cabin, from which both the signals and bridge are worked. The bolts are electrically detected, so that unless the bridge is "Down", gate "Open" for railway, and bolts "In", a train cannot be accepted or the signals lowered. The bridge stands normally bolted with gates open for railway and roadway traffic. To open bridge for river traffic (see Fig. 16):

1. The toll gate and wicket must be shut and locked by a key A, which is normally in the toll gate, and cannot be taken out or released until the gate is shut and locked.. This key is used to unlock a lever on the girder working the catches and gates across the road at the other end of the bridge. The gate is closed and locked, permitting key B to be taken out and used to unlock No. 8 lever, being the bridge bolt lever in the signal cabin. No. 5 lever and the signal levers must be replaced, and No. 8 must then be released on the instruments by the signal cabins on either side, viz., Middle Junction (Sittingbourne) and Queenborough.

2. No. 8 lever is pulled, releasing the capstan, locking the signals and blocking the instruments.

3. The capstan is then rotated to withdraw the bolts, and close the gate across the railway. The wheel is then locked by hand, by means of the catch C. The lock D falls by its own weight, keeping this catch in place.

4. The controlling lever can then be actuated to raise the bridge, which by breaking the contacts at E also locks the capstan in its over position.

To reopen the bridge for railway and roadway traffic:

The controlling lever must first be reversed to lower the bridge, and the capstan cannot be rotated until the bridge is down. This is ensured by the contacts E, the adjustment of which is so fine that if the bridge is not down by one six-

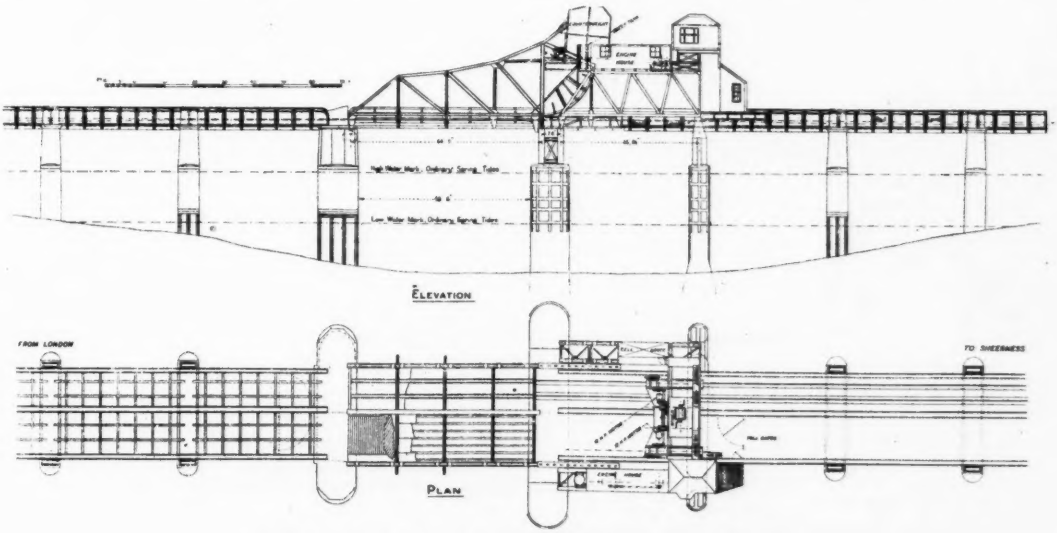


Fig. 11. South Eastern & Chatham Railway—Swale Bridge.

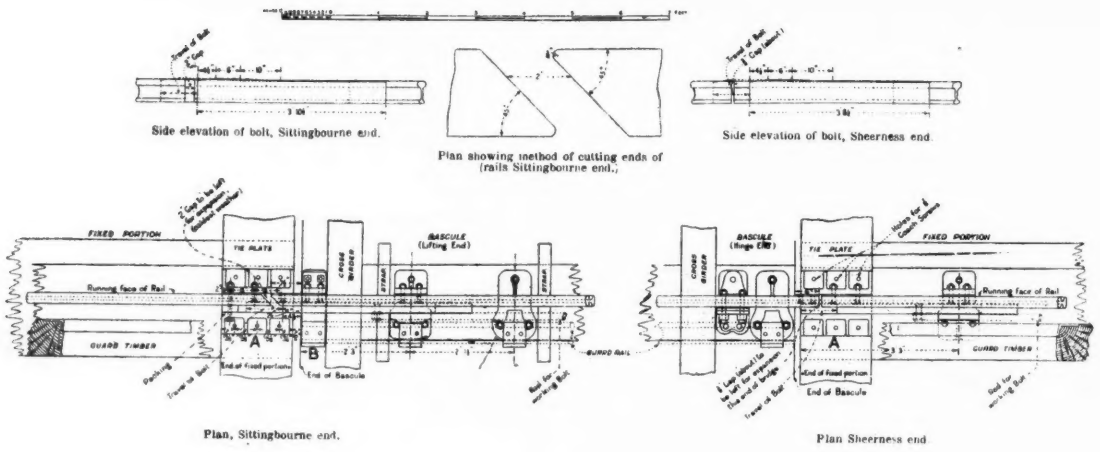

Side elevation of bolt, Sittingbourne end.
Plan showing method of cutting ends of rails Sittingbourne end.
Side elevation of bolt, Sheerness end.
FIXED PORTION
BASCULE (Lifting End)
Running face of Rail
GUARD TIMBER
End of Bascule
Plan, Sittingbourne end.
Plan Sheerness end.

Fig. 12. South Eastern & Chatham Railway—Swale Bridge.

teenth of an inch only, the capstan remains locked. The bridge being down, the foot plunger must be used to free the hand lock holding the capstan wheel, which can then be taken out, and the foot plunger must again be used to take out the back lock of the capstan, which can then be rotated to bolt the bridge, and open the railway gate.

The bolt lever is replaced and locked by key B. The instruments must be lifted to "locked" position, locking the bridge bolt levers, and then plunged to release the block instruments at Middle Junction and Queensborough. No 5 lever and the signal levers are then pulled. Key B is taken to open the gate across the road, and left in the lever, releasing key A, which is used to unlock the toll and wicket gates.—Note: With No. 5 lever normal, the "Up" signal levers and "Down" signal levers interlock.

Figure 18 shows the electrical locking arrangements at Clachnaharry bridge. A and B are two train tablet stations, having a branch railway and the canal swing bridge between them. The points at Canal Basin Junction are operated by inserting the tablet for the section in a ground frame lock.

In the normal position, and when the line is clear, a train can enter the section with a tablet from A to B or vice versa, or the swing bridge can be opened for the passage of vessels, and the arrangement is such that when a train is in the section, the swing bridge is locked and cannot be opened, or should the bridge be open, no train can enter the section.

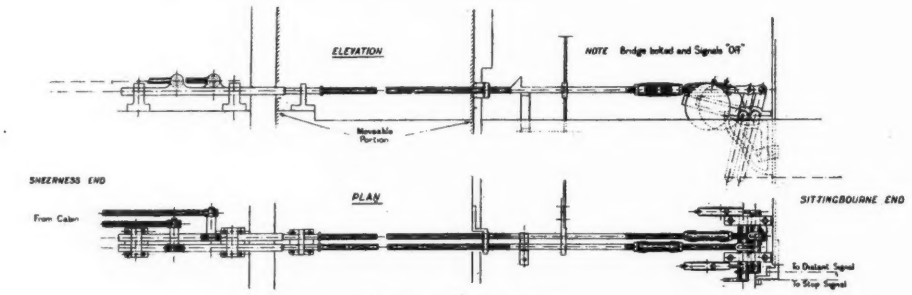


Fig. 14. — Signal disengager.

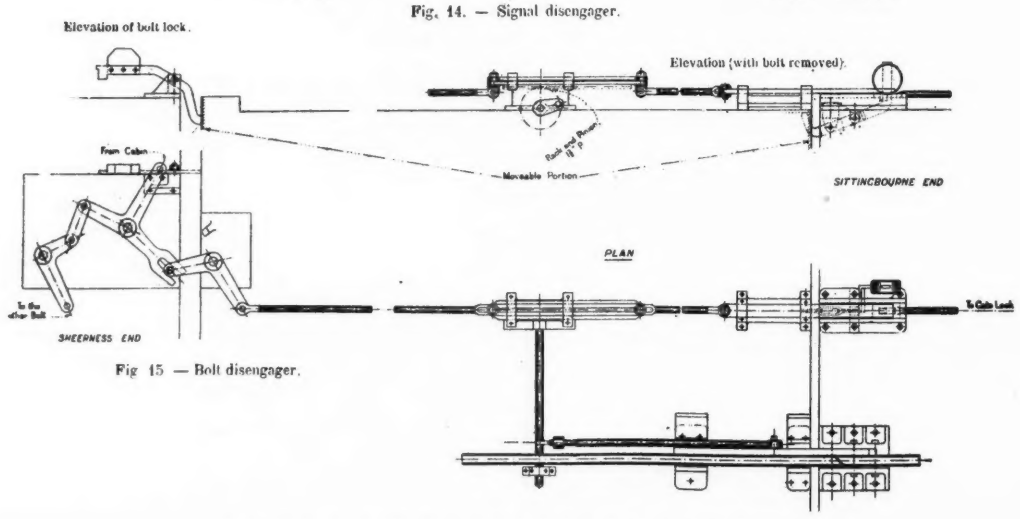
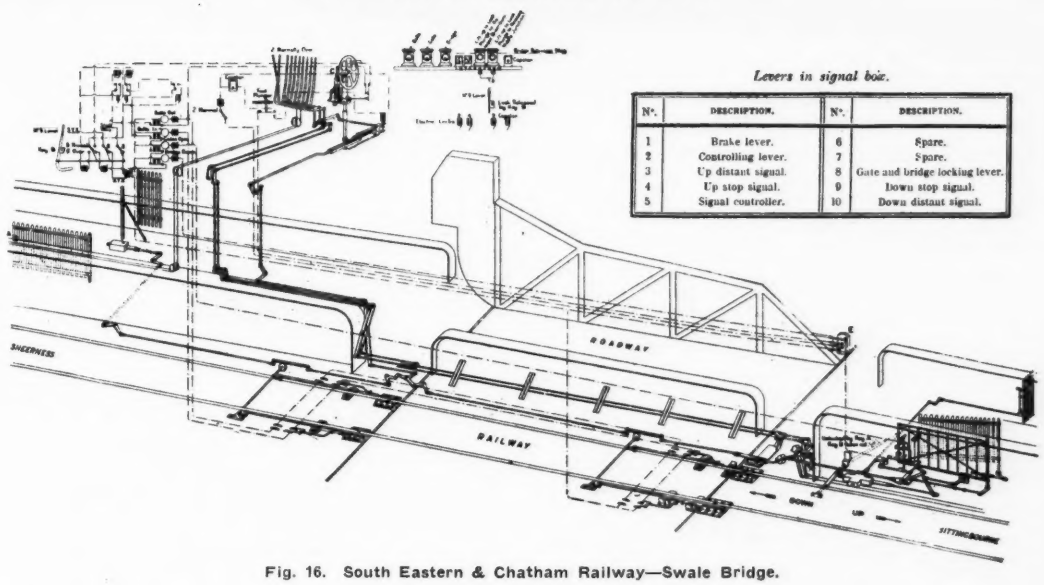


Fig 15 — Bolt disengager.

Figs. 14 & 15. South Eastern & Chatham Railway—Swale Bridge.



Levers in signal box.

N°.	DESCRIPTION.	N°.	DESCRIPTION.
1	Brake lever.	6	Spare.
2	Controlling lever.	7	Spare.
3	Up distant signal.	8	Gate and bridge locking lever.
4	Up stop signal.	9	Down stop signal.
5	Signal controller.	10	Down distant signal.

Fig. 16. South Eastern & Chatham Railway—Swale Bridge.

The tablets are joined up in the usual way by a line wire from A to B, which runs through intermediate switch springs 3 and 4 at canal bridge cabin. When a tablet is taken out at A or B, the bridge lock wire is cut at SS-A, or SS-B. The canal bridge electric lock on lever L cannot, therefore, be released, as will be seen on the diagram. Should the swing bridge require to be opened tapper No. 1 is pressed, and there being no tablet out of the instruments at A and B, the local current through lock 1 releases L (the bridge lock lever) which can then be pulled over, and stud S on LB cutting the tablet line wire at the springs 3 and 4. The tablet circuit between A and B is, therefore, disconnected, and no train can enter the section until the bridge is closed.

A branch railway to the canal basin branches off between A and the bridge. The points are operated by inserting an A to B tablet into the tablet mechanical lock TL fixed to L2. The lever is then pulled over, and becomes electrically back locked by lock 2. At the same time, the stud S on LB2 con-

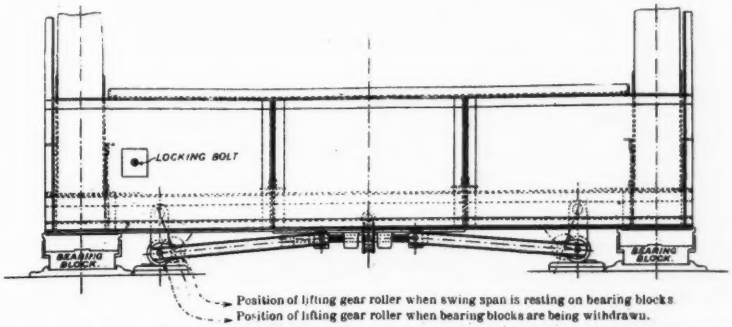

LOCKING BOLT
BEARING BLOCK
BEARING BLOCK
Position of lifting gear roller when swing span is resting on bearing blocks
Position of lifting gear roller when bearing blocks are being withdrawn

Fig. 17. — Great Southern & Western Railway. — Viaduct over river Barrow. Lifting gear arrangement for swing span.

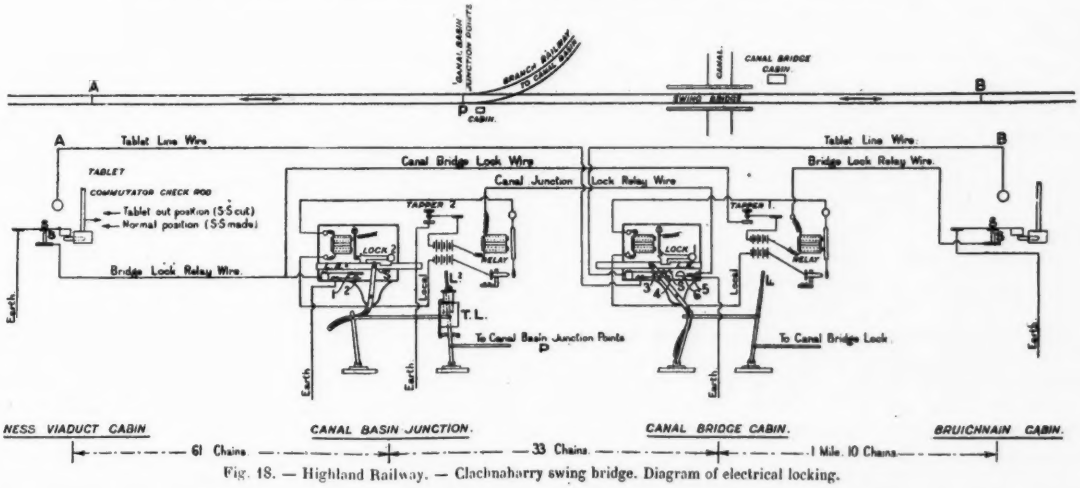


Fig. 18. — Highland Railway. — Clachnaharry swing bridge. Diagram of electrical locking.

Figs. 17 & 18. Viaduct and Bridge.

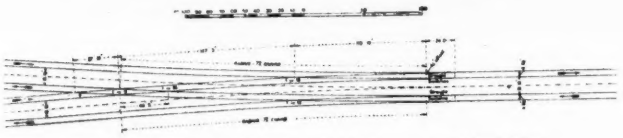


Fig. 19. — Plan of best possible junction with 1 in 8 diamonds and widened six-foot.

Fig. 20. — Great Western Railway. — Cogload junction.

Speed of trains over up Exeter direct line about 50 miles per hour. — Speed of trains over all other lines from 60 to 70 miles per hour.

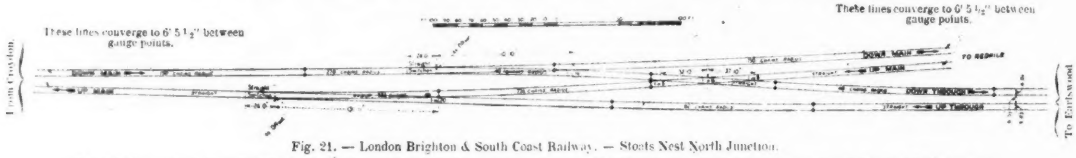

These lines converge to 6' 5 1/2" between gauge points.
These lines converge to 6' 5 1/2" between gauge points.
From Croydon.
To Earlswood.

Fig. 21. — London Brighton & South Coast Railway. — Stoats Nest North Junction.

Speed of trains over down lines about 50 to 55 miles per hour. — Speed of trains over up main line about 60 miles per hour. — Speed of trains over up through line about 70 miles per hour.

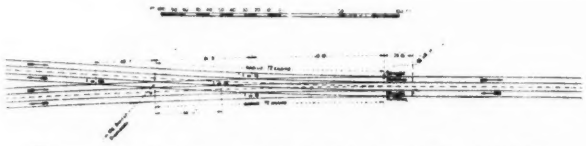


Fig. 22. — Plan of best possible junction with switch diamonds and standard six-foot.

Figs. 19 to 22. Plans.

nects the springs 1 and 2 of the bridge lock relay wire, thus allowing the swing bridge to be operated, while the branch train may be for some considerable time on the branch railway.

When the branch train returns to the junction, tapper 2 must always be pressed to release L2 and to get the tablet out of the mechanical lock TL. If, however, the swing bridge is open, the springs 5 and 6 are cut by the stud S on LB and consequently tapper 2 becomes inoperative, and the train must wait on the branch until the bridge is closed, and the lever L replaced. In pulling L2 back to normal, to regain the section tablet, the springs 1 and 2 are cut, and the bridge cannot be operated until the train returns to A, and SS is restored by inserting the tablet and clearing the line.

Telephonic communication is always maintained between A and B and the intermediate places.

Figure 4 is a diagram of the electric control of Carlton Colville swing bridge.

The bridge stands normally open for railway traffic, and is worked from a motor house fixed on the bridge.

To open the bridge for water traffic:

The bridgeman in the motor house must verbally advise the signalman in the swing bridge box, so that the latter may release his bolt lock lever No. 5. The act of pulling over this lever switches on the current, and the bridgeman then works the bridge from the motor house. The bridgeman must:

1. Place main switch in "On" position.
2. Pull out lever working bridge catches.
3. Put on starting switch of pump motor; move the valve lever which will admit pressure to the hydraulic rams, and slightly lift the ends of the bridge; pull over the wedge levers which withdraw the wedges from each end of the bridge; switch off the pump motor; and, lastly, reverse the valve lever, allowing the ends of the bridge to drop.
4. Actuate the controlling handle of the motor, which will swing the bridge. This bridge can be stopped in any desired position by actuating the break lever steadily.

To close the bridge and make all fit for railway traffic, the above operations must be reversed, and after the bridgeman has satisfied himself that the bridge is in position, and all is right for the passage of a train, he must at once verbally advise the signalman in the swing bridge box, so that the latter may replace his bolt lock lever in its normal position, which will cut off the current for working the bridge.

No. 5 lever cannot be pulled unless the up and down plungers, Nos. 4 and 9 levers and signal arms, and No. 3 lever, are all normal.

The following electric indicators are provided in the signal box and motor house:

1. Showing when the bridge bolt locks are "In", "Out", or "Wrong".
2. Showing when the wedge blocks are "Out", "Under", or "Wrong".
3. Showing by a white disc when the wedge lever may be pulled over or put back, the normal position of the disc being red.
4. Showing bridge "Home".

Unless the indicators (1, 2 and 4) point to the right, and the indicating discs are in their normal positions, the signalman cannot accept a train from the signal box on either side of the swing bridge, or lower any of his signals, or take off his slot on the Oulton broad junction up advanced starting signal, although he may have received "Clear" from the signal box in advance.

In conclusion, it appears that swing bridges have little bearing on the question of speed limitations. Where speed restrictions are enforced at the present time, they might generally be eliminated by improvement of the approach lines, or other conditions, without reference to the bridge. Swing bridges, however, have an important bearing in limiting the volume of traffic over the railway by reason principally of the time taken in passing the waterway traffic through. Much might be done to improve matters in this respect by the provision of mechanical means, to assist the traffic on the waterway through the bridge openings.

Elimination of Speed Restrictions at Junctions.

This is a question of far greater importance than that already dealt with in connection with swing bridges, from the fact that in the United Kingdom mostly all of the large systems of railways have been built up by the amalgamation of a number of smaller railways, laid and constructed in the first instance principally for local requirements, rather than for through main line traffic, junctions being, in consequence, very numerous in proportion to the length of the lines. In many cases in the early days of railway location, large towns stoutly opposed railways being brought into their midst, with the result that in some instances, the railways were constructed at a considerable distance from the towns. The requirements of trade and the public have, from time to time, necessitated the making of loops to bring the railways nearer to the business parts of the town, and this has entailed the construction of further junctions. It has also become imperative in many cases, to construct loop lines, so as to avoid interference with traffic in the stations, and by so doing to straighten and shorten the line and make improved running for fast and non-stop trains, with the result that in each such case, further junctions have been brought into existence.

As an illustration of the very important effect of junctions in the United Kingdom on the question under consideration, and on the expense of working and maintenance of the railways, it may be mentioned that there are about 3,500. Junctions (excluding as far as possible all junctions for goods yards, docks and in such positions) which gives one for each 6.5 miles of route.

It is very desirable from the point of view of increase of speed, safety and comfort, and for economy of maintenance, to improve such of these junctions as are not suitably designed for fast traffic, and which thus necessitate special speed restrictions being imposed, thereby constituting a permanent obstacle to fast running. In the case of maintenance, the extra expense caused by running at anything like high speeds through junctions not designed for fast traffic, is a heavy item, both for rolling stock, permanent way, and signal connections.

In bringing about safe and smooth running, the great importance of transition curves in the running of roads is well appreciated by all engineers responsible for the maintenance of railways, but the presence of transition curves is of much greater importance in the case of curves immediately approaching and leaving junctions, in order to secure the best and smoothest running through the junctions, and to avoid what inevitably must happen without such transition curves, viz., a swing or a jerk at the entrance to any curve from the straight and departure from the same to the straight. Should derailment due to a curve occur, it almost invariably takes place at the entrance to the curve, owing to the absence of such treatment, rather than to the presence of the curve itself, and it is at these points where discomfort is most usually experienced. Again, with the approach curves so treated, the train more readily accommodates itself and travels much more comfortably over the curve and through the junction, and the necessary absence in most cases of sufficient super-elevation is not so appreciably felt. The question of transition curves, and kindred subjects, as affecting good running, has been previously so very fully dealt with, that I do not propose to enter upon the subject in this paper, further than to point out that the provision of such curves bears very directly on the question of the elimination of speed restrictions, for where they are provided, trains can, with safety, be run at a higher speed through junctions, than would be desirable without them.

I will now consider some junctions which have been laid in on main lines for fast and heavy traffic, and through which high speeds are regularly run. Plans of some of these junctions are also given, with particulars of curves and angles of crossings and other details, and on the same is shown the rate of speed ordinarily run through them in every day working.

I have thought by giving a few illustrations and particulars of junctions in every day use, that a more useful purpose would be served than by attempting to treat the subject from a theoretical standpoint. I am hopeful that this simple method of dealing with the subject will convey information in a practical form for dealing with the improvement of existing conditions at junctions not originally laid out for high speeds, but through which a high rate of speed is now demanded.

Fig. 23. — London Brighton & South Coast Railway. — Windmill bridge junction.

Speed of trains over main lines about 60 miles per hour. — Speed of trains through crossover roads from down main to down relief about 45 miles per hour.

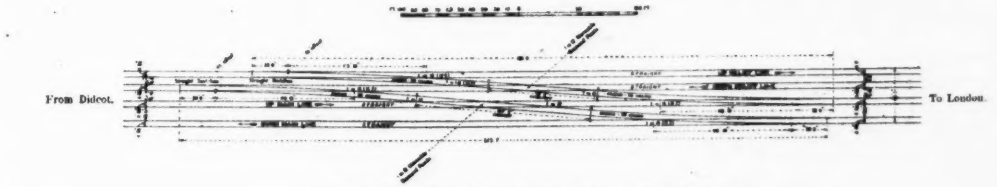


Fig. 24. — Great Western Railway. — Moreton cutting crossover junctions.

Speed of trains over main lines about 65 miles per hour. — Speed of trains through crossover roads about 35 miles per hour.

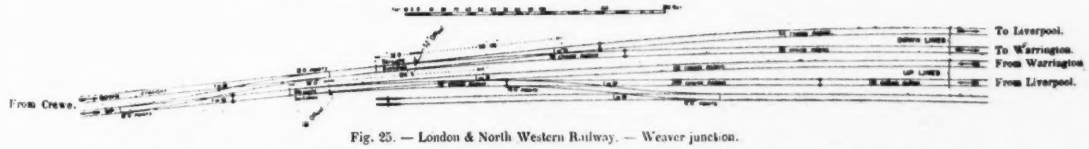


Fig. 25. — London & North Western Railway. — Weaver junction.

Speed of trains over lines to and from Warrington about 55 miles per hour. — Speed of trains over lines to and from Liverpool about 50 miles per hour.

Figs. 23 to 25. Plans.

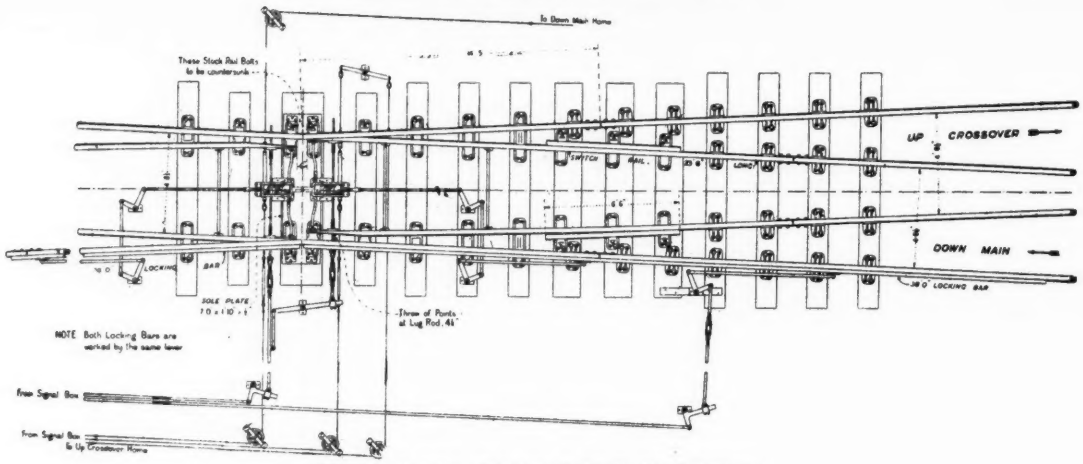

To Down Main Home
These Stock Rail Bolts to be countersunk
UP CROSSOVER
DOWN MAIN
SWITCH RAIL
LOCKING BAR
SOLE PLATE
Throw of Points at Lug Rod, 4½"
NOTE Both Locking Bars are worked by the same lever
From Signal Box
From Signal Box to Up Crossover Home

Fig. 26. London, Brighton & South Coast Railway.

Owing to the Board of Trade not recommending the use of diamond crossings flatter than 1 in 8 (7° 9′ 10″) the best radius that can be obtained for the branch line, with the standard distance of 6 ft. 5½ in. (gage points) between up and down roads is 20 chains, when the trunk line is straight. With a junction such as this, a speed restriction would be essential. If, however, the gage points be widened to 13 ft. 10 in., and a 1 in 16 (3° 34′ 47″) ordinary crossing be used, and a 1 in 8 fixed diamond crossing, then the curve would be flattened from 20 chains radius to 36 chains, giving a very vast improvement on the conditions first described, from the point of view of comfort, and the increased speed which might be run through the junction. When, however, both trunk and branch lines are curved equally, in opposite directions, and still adhering to 1 in 8 fixed diamond crossing, a radius of 40 chains can be obtained, keeping to the standard of 6 ft. 5½ in. (gage points). A junction so constructed forms no material obstacle to high speeds.

Again, on the assumption that both trunk and branch lines are curved equally in opposite directions, but that the standard width of 6 ft. 5½ in. (gage points) is increased to 13 ft. 10 in. and 1 in 16 ordinary crossings and 1 in 8 fixed diamond crossings, curves of 72 chains will be obtainable, the up and down roads being brought back by easy curves to their standard distance apart, beyond the diamond crossings. (See Fig. 19.) A junction laid out as shown on Figure 19 gives, in my

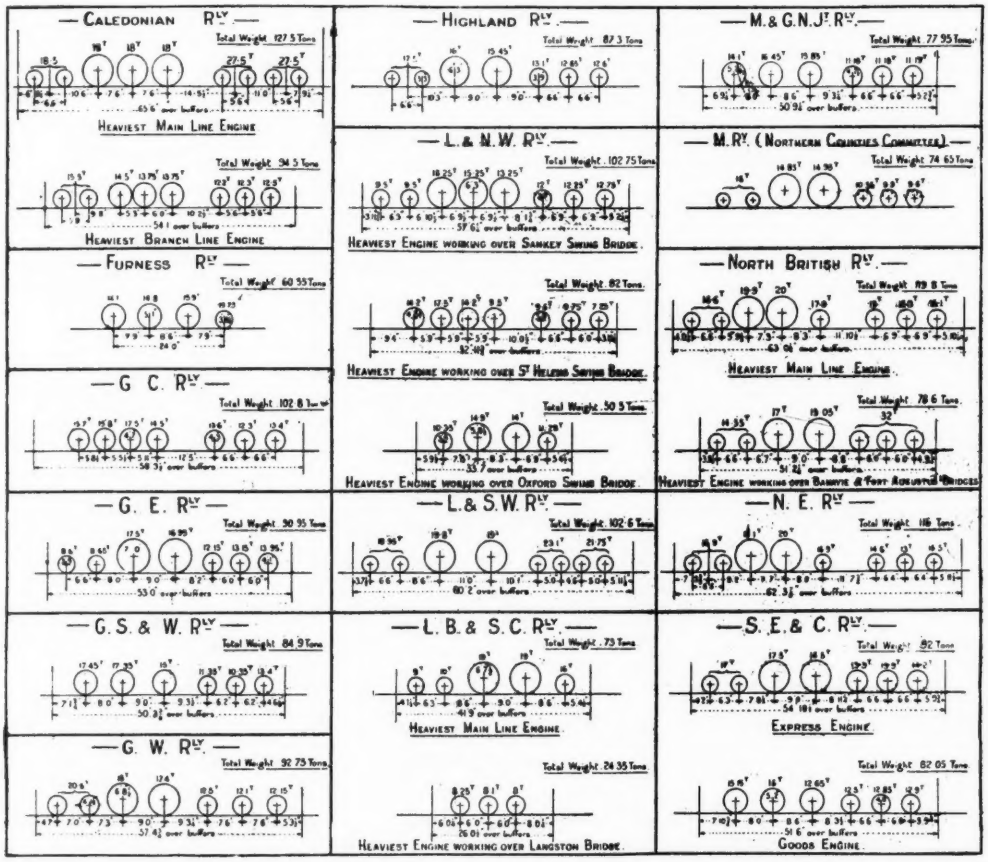

— CALEDONIAN R.LY. —
Total Weight 127 5 Tons
HEAVIEST MAIN LINE ENGINE
Total Weight 54 5 Tons
HEAVIEST BRANCH LINE ENGINE
— HIGHLAND R.LY. —
Total Weight 87 3 Tons
— L. & N. W. R.LY. —
Total Weight 102 75 Tons
HEAVIEST ENGINE WORKING OVER SANKEY SWING BRIDGE
— M. & G. N. J.T. R.LY. —
Total Weight 77 95 Tons
— M. R.Y. (NORTHERN COUNTIES COMMITTEE) —
Total Weight 74 65 Tons
— FURNESS R.LY. —
Total Weight 60 55 Tons
— G. C. R.LY. —
Total Weight 102 8 Tons
— NORTH BRITISH R.LY. —
Total Weight 119 8 Tons
HEAVIEST MAIN LINE ENGINE
Total Weight 78 6 Tons
— G. E. R.LY. —
Total Weight 90 95 Tons
— L. & S. W. R.LY. —
Total Weight 102 6 Tons
— N. E. R.LY. —
Total Weight 116 Tons
— G. S. & W. R.LY. —
Total Weight 84 9 Tons
— L. B. & S. C. R.LY. —
Total Weight 73 Tons
HEAVIEST MAIN LINE ENGINE
— S. E. & C. R.LY. —
Total Weight 92 Tons
EXPRESS ENGINE
— G. W. R.LY. —
Total Weight 92 75 Tons
Total Weight 24 35 Tons
HEAVIEST ENGINE WORKING OVER LANGSTON BRIDGE
Total Weight 82 05 Tons
GOODS ENGINE

Fig. 27. Diagram of Axle Loads of the Heaviest Engines Working Over Swing Bridges in the United Kingdom.

opinion, an excellent junction and the best possible with the limitation of using fixed 1 in 8 diamond crossings. Through such a junction, properly and truly maintained, all speed restrictions may be eliminated.

Figure 20 shows a junction very similar to Figure 19 with a minimum radius of 56 chains. A speed of 50 miles per hour is regularly worked over the up Exeter direct line, and speeds ranging from 60 to 70 miles per hour over any of the other lines.

Figure 21 shows a somewhat similar junction, where, with every degree of comfort, trains run over the down lines at speeds varying between 50 and 55 miles per hour, over the up main line at about 60 and the up through at about 70 miles per hour.

The three junctions described above are, as will be seen from the plans, laid out with fixed 1 in 8 diamond crossings.

It is, however, not always possible to increase the distance between the up and down lines, and to meet this difficulty, switch diamonds may be used of flatter angles than is permissible for fixed diamonds. When these are used, and the trunk and branch lines both curved equally in contrary directions, 72 chain curves can still be obtained throughout the junction, and there is no necessity for any increase whatever in the width of the lines between the 6 ft. 5½ in. gage points. Switch diamonds are useful, not only for ordinary junctions, but for through cross-overs between fast and slow roads, where these run parallel to one another, giving 36 chain curves with ordinary crossings of 1 in 16 when the main lines are straight. (See Figs. 22 and 24.) The 36 chain curves, shown in Figure 24 can, however, be improved by adopting flatter crossings, in which case the cross-overs can be run through at any reasonable speed the ordinary road is capable of carrying.

Figure 23 shows a junction through which a heavy and fast taffic is regularly worked, and the particulars as to the speeds are set out thereon.

Figure 26 shows the switch diamonds in use on the London, Brighton & South Coast Railway. By the use in junctions of switch diamonds, which can be made to any degree of fineness, and with ordinary crossings as flat as 1 in 21 (2° 43′ 40″) together with long switches, there is no need for any material reduction of speed below the highest which can be run on the plain road of the railway. A further advantage is that switch diamonds are less subject to wear and tear than fixed diamonds, as the wheels have a continuous surface to run over, there being no gap in the rails, as is necessarily the case with fixed diamonds.

Figure 25 shows a "Flying" junction, which is the best form of junction where the line is crowded, by reason of the greater freedom in passing traffic through, and the absence of conflicting operations. Having regard to the fact that these advantages reduce the checking of other trains, such junctions may be looked upon as doing something towards the elimination of speed restrictions.

In conclusion, it is evident that junctions in most cases form a serious impediment in the working of railways, the majority necessitating a limitation of speed. It is equally evident from the illustrations given of improved junctions in every day use, that with careful design and construction, it is generally possible to have junctions that form no material impediment to fast running. Where the traffic requirements demand the entire elimination of speed restrictions at junctions such improvemnts could generally be made on the trunk lines clear of large towns, after the manner indicated upon the designs shown on the plans and as described in the paper because, as a rule, there would be no obstacle in the way of improvement in the lay out, except want of land, the acquisition of which would not be a serious consideration. In and around large towns, however, it will not generally be an easy matter, within the limits of reasonable expenditure, to acquire sufficient land to make the remodeling commercially possible, nor is it really so necessary, as mostly the lines over which high speeds are maintained through towns, are on the trunk lines and the junctions affect only the running from the trunk lines to the branch or subsidiary lines.

Tunnels, Especially Subaqueous

(Continued from Page 122)

The Shield Method.—The construction of subaqueous tunnels of large extent through soft materials under the beds of streams without removal of the cover has been made possible by the shield method in connection with the use of compressed air and metallic tunnel lining. It has succeeded where attempts to tunnel by ordinary mining methods with or without compressed air and with the use of brick lining have failed. Consequently it may be looked upon as the most perfect method of subaqueous tunnel construction.

History.—The shield method of driving subaqueous tunnels was invented by Mark Isambard. Brunel. This remarkable engineer, born in Brittany, educated for the ministry, trained alike in seamanship, surveying, architecture, timber production and manufacture, inventor of shoemaking machinery, improved copying pens, methods of polishing tin foil, etc., applied to the construction of the Thames River Tunnel the best of his skill and experience, and did what the best engineers of his day could not do. The tunnel was first proposed in 1798 by Ralph Dodd, but abandoned. In 1894 under act of Parliament a tunnel from Rotherhithe to Limehouse was begun when a shaft 11 feet in diameter was sunk 42 feet with a view to the commencement of the horizontal excavation. Work was soon suspended, to be resumed with a diameter of 8 feet in 1807 by the Cornish engineer, Trevithick, and a small heading carried 923 feet, or to within 150 feet of the opposite shore. Trevithick then made an opening in the top of the heading to test the alignment with the result that he and his party were almost drowned, the heading was filled up and the work abandoned. After various plans had been proposed for the construction of the tunnel it was taken up in 1824 by Brunel, who sunk a new shaft of brick work 50 feet in diameter, 42 feet high and 3 feet thick, built on a metal cutting edge bodily into the ground by what are now called caisson methods. From this shaft he proceeded with the tunnel, which, when completed, was a brick structure 38 feet by 22 feet 6 inches enclosing two horseshoe shaped tubes 16 feet 4 inches high by 13 feet 9 inches wide separated by a 3 feet 6 inch brick wall, pierced occasionally with openings. The shield was placed in position by January 1, 1826 It consisted of 12 great frames 22 feet high and 3 feet wide, made of cast iron with a cutting edge top and bottom and divided into three stories, thus presenting 36 cells or working platforms both front and back for the workmen, namely the miners, by whom the ground was cut down in front and the bricklayers, who simultaneously with the advance of the shield placed the brickwork of the finished structure. The leaves of the shield were advanced by powerful screw jacks, and the vertical face was protected by horizontal poling boards which could be handled separately and pushed forward as the ground was excavated. The water broke in several times, impending the work, to be stopped by bags of clay dumped into the chasm; financial conditions also interfered to delay the completion until 1843, but the shield was a success from the start. It embodied all the foundamentals of the modern type except the tail tube, which came in use with tunnels of circular form.

The annular shield and cast iron lining were first used by James Henry Greathead. Greathead was born in Grahamstown, Cape Colony, on August 6, 1844, came to England in

1859 and in 1864 became a pupil of P. W. Barlow, through whom he became acquainted with the shield method of tunneling. Barlow had a strong belief in the shield and was the author of a scheme to facilitate London traffic by the construction of underground railroads running in cast iron tubes built with its aid. To show what the method could do it was resolved to make a subway under the Thames near the Tower, but the trouble encountered by Brunel in the Thames Tunnel made engineers hesitate to undertake the subway, though it was of much smaller dimensions—6 feet 7 inches in diameter (some say 8 feet 0 inches). At this juncture Greathead offered to take the contract and he successfully carried it through without resort to the use of compressed air, which Barlow in 1867 suggested might be employed in water bearing strata. In 1884 Parliament authorized the construction of the City and South London Railway, to be worked by the Hallidie system of cable traction. This was begun in 1888 and the tunnel was driven by means of the Greathead shield, compressed air being used in water bearing strata when necessary. During the progress of the work electric traction became so far developed as to be superior to cables and when the line was opened it was an electric one. The railroad is 3 1-6 miles long entirely underground and consists of two 10 feet 6 inches cast iron lined tunnels substantially parallel to each other, which converge into a single tunnel at the terminal.

Where Barlow got the idea of lining tunnels with cast iron does not appear. It is significant that coal mine shafts have been lined with cast iron tubbing rings for more than 50 years, and it is more than likely that their use in tunnnels is the application to horizontal passages of a method of construction long approved by English and European practice in sinking deep shafts through soft and water bearing strata under difficult conditions, and is but another proof of our preposition that tunneling is essentially a mining operation.

Compressed air was first used in the United States in 1880 by D. C. Haskin in the Hudson River Tunnel, where an attemtp was made to drive a double track tunnel through the mud and silt with a pilot tube 6 feet 6 inches in diameter advanced 30 to 40 feet ahead of the main tunnel, to form a firm support for the iron plates of the latter by means of radial screws. Compressed air at a pressure of 20 pounds per square inch prevented the weight of silt and water from crushing the plating and flowing into the tunnel.

Where open gravel or running sand heavily charged with water are met a diaphram must be fitted to the shield. Mallet proposed in 1858 to carry in this way a tunnel under the English Channel. The pneumatic shield designed by Sir Benjamin Baker is the outcome of this idea. His shield is supported against external pressure by girders 6 feet apart. Horizontal shelves of steel plates with cutting edges are spaced about 4 feet apart, and the face of the shield is closed by vertical plates, slides and doors, so as to admit the materials being excavated, while the compressed air prevents the influx of water. Where firm clay is met the shield plates may be unbolted. When sufficient material has been excavated the shield is advanced by hydraulic pressure and the lining built under the tail of the shield. The Blackwall Tunnel, 3116 feet long and 24 feet 3 inches inside diameter, built in 1892 to 1897, was built with a shield 28 feet 8 inches outside diameter, 19 feet 6 inches long, with bulkheads, movable shutters and other important features embodied in Mr. Baker's design. The shield was pushed ahead by twenty-eight 100-ton hydraulic jacks abutting against the cast iron lining, which was placed in position by two hydraulic erectors. This type of shield is that used on the Pennsylvania Railroad Tunnels into New York City.

Various plans have been suggested for the removal of the material in front of the shield. Mr. Greathead would effect it by a closed current of water carrying the stuff through the shield from front to back. In part of the Hudson Tunnel work the shields were driven through mud and slit, plowing it aside.

The first American subaqueous tunnel constructed and completed by the shield method was the St. Clair under the St. Clair River at Sarnia, built inside a cast iron lining, under Joseph Hobson, Chief Engineer, Grand Trunk Railroad. The shields were 21 feet 6 inches in diameter and 15 feet 6 inches long, made of 1 inch steel plates stiffened by five diaphrams dividing it into 12 cells. There were 24 hydraulic jacks, each capable of 125 tons pressure, but the total power used did not exceed 1800 tons. Each lining ring is 18 inches long, made up of 13 segments and a key. Each segment weighs 1050 pounds and the total weight of the cast iron lining is 27000 tons.

Parts of the Shield.—It will be noted from the discussion that the construction of the shield varies somewhat in accordance with the character of the work under construction. The Brunel shield was rectangular in form to conform to the outline of his tunnel section. Modern subaqueous tunnels are usually circular in order to get the benefit of the full strength of the circular form of section. This explains to some degree why the circular form is better adapted also to the shield.

The system of tunnels under the North and East Rivers, by which the Pennsylvania Railroad gains access to New York City and Long sland, is the greatest piece of subaqueous tunnel construction ever attempted. The length of the work and different conditions naturally to be expected required careful consideration in the design of the tunnel shields, air chambers, etc. The contractors for the North River Tunnels were the O'Rourke Engineering Constructing Company, and for the East River Tunnels S. Pearson & Sons, Inc. The latter contractors had built the Blackwall Tunnel in London by the use of a shield patterned after the design of Sir Benjamin Baker's. The Chief Engineer on the North River Tunnels was Mr. Charles M. Jacobs, who had been Chief Engineer of the old Hudson River Tunnel and also of the other tunnels projected and built under the Hudson River. The forms of the shields used in the North River Tunnels, therefore, varied somewhat from those used by Pearson in the East River Tunnels. The essential features, however, were, of course, the same. The external diameter of the shield was 23 feet 6¼ inches; its length 15 feet 2⅜ inches. The skin of the shield was made up of three steel plates ¾ inches, ⅝ inches inches and ¾ inches respectively, making a total thickness of 2⅛ inches, thus leaving an inch space all around between the tail of the shield and the tunnel lining. The tail of the shield overlapped the lining a maximum of 6 feet 4½ inches during ordinary working and a minimum of 2 feet during the operation of taking out any rams for repairs. This overlap also permitted the removal of any segment which might be fractured during the process of shoving the shield against it without exposing the dangerous ground.

(Continued in April Issue)

A northbound train in the Hudson tunnel, New York City, collided with great force into the rear of a five-car empty train at the temporary terminal of the line at the Twenty-third street station. Two devices to mitigate the dangers of collision with which the company had equipped its cars are credited with preventing serious results of the crash by officers of the Hudson & Manhattan R. R. All of the Hudson company's cars are of steel, built on what is known as the full bridge truss type. They are equipped with anti-telescoping anvil buffers and an "anti-climbing" device to prevent buckling in collision.

Method of Laying Track on the Pecos and Northern Texas Ry.

As is well known the Atchison, Topeka & Santa Fe Ry. is making a great many improvements, extensions and betterments, and among these is a new Gulf-to-the-Coast line in Texas, which is being built, under the charter of the Pecos & Northern Texas Ry. from Coleman, Texas to Texico, N. M., with numerous branches and feeders. Tracklaying on the Western end of the line has been going on for some time. The manner in which this track is being laid is of particular interest to engineers, as it is being done with a Hurley tracklaying machine, which machine has attracted considerable attention in the last few years. The P. & N. T. Ry. decided to use the Hurley machine after an inspection by the Superintendent of Track, of one of these machines in operation on the M. & N. E. R. R. in Michigan.

Thus far some good work has been accomplished, considering the poor labor—being of the Mexican variety—with which they have had to contend. On one occasion the machine, with 36 men, laid a mile and a quarter of track in about five hours, which is not unusual. The number of men used was increased somewhat owing to the fact that the track is being laid with "square" joints, necessitating the use of a few more men in front and on the rail car in the rear.

The cost of actually laying track largely depends upon the amount of labor used, the amount of track laid per day with this force and the expense of motive power in connection with this part of the work. As is well known the old "pioneer car" methods require a force of men in the front to carry out and distribute the ties and rails, and further, a locomotive pushes the train and is forced to stop at every joint while the connection is being made, resulting, in the aggregate, in a great deal of wasted time.

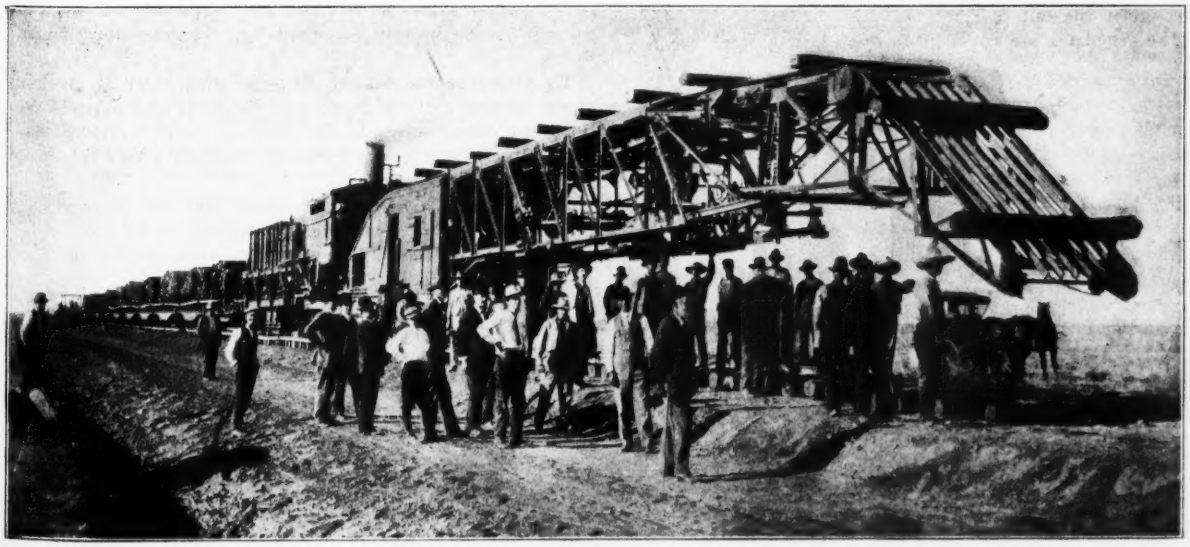
The Hurley machine is an entire departure from the old methods, handling the material with greater speed and much less labor. In the first place it is equipped with its own engines and boiler, which furnish power for propelling it and the material train of 20 cars, more or less depending on the grade, thus saving the cost of maintaining a locomotive and crew. This is a feature that appeals very strongly to railroads.

The machine is geared so that it moves constantly, but slowly, the speed being about 30 feet per minute; thus no time time is lost in stopping to make the rail connections.

The manner in which the material is handled is radically different from the old methods. In place of "trams," etc., each flat car in the material train is equipped with a pair of rollers, one on each side, over which the rails, connected in the rear by one bolt in each end, are drawn through the machine by means of two seats of compression rollers located on each side, in the machine. The ties are rolled upon the rails moving forward, thus using the rails as tie conveyors to the machine, and when the ties reach the machine they are picked up by endless chains, taken over the top of the truss and automatically distributed in position on the roadbed, as the machine, constantly moving forward, drops each tie a little ahead of the one previously deposited. Two men only are required to straighten them. This is one of the great labor-saving features of the Hurley machine. The truss is long enough so that the ties have been distributed by the time the rails are ready to be lowered to position. The photograph shown herewith very clearly illustrates this method of distributing the rails and ties.

These machines are built and leased by the Hurley Track Laying Machine Co., of Chicago, and further information may be had in their interesting and well illustrated booklet, "Laying Track," which will be sent to anyone upon request.

Two years ago there occurred at a powder mill located in Indiana an explosion which reduced the factory buildings to ashes, and even damaged a section of the town in which the factory was located. This is all ancient history—in fact, so old that the matter has probably been entirely forgotten by you. Do you remember the cause? It was a hot box. That's the whole story; a hot box—but it resulted in a heavy loss of life and property. Fortunately, the results of hot boxes are rarely as dire as they proved in this case, but there is always the chance of loss in every case. It may be the ruining of the bearing or journal, it may be the tieing up of the plant for hours, it may be a fire that destroys a portion or all of the plant—there is no way of knowing exactly what will result from any hot box. There is one perfect insurance, however, against all frictional damage. It is Dixon's Flake Graphite. This lubricant will absolutely pervent excessive heating of bearing parts as well as cutting and seizing. Dixon's Flake Graphite attaches itself directly to the metal surfaces, filling in the microscopic depressions and becoming fastened upon the microscopic projections that exist in all metal surfaces. Thus direct contact of metal-to-metal is made impossible, and we have what may be termed a "graphited contact" which lowers friction, reduces wear and prevents damage.



Method of Laying Track on the Pecos and Northern Texas Railway.

Tie Plates anb Screw Spikes.

The questions relating to the use of tie plates and screw spikes have been studied very carefully by one of the manufacturers, and they have designed screw spikes and tie plates after the conclusions derived from the careful investigation. The screw spike is one of the latest improvements in American track construction, and it is one of the betterments that relates particularly to maintenance. We have reached a period in track construction where we draw a balance between first cost and cost of maintenance, and so it was about two years ago that we settled on the screw spike as a matter of economy in maintenance. The investigation, referred to above, consisted of the solution of the following questions:

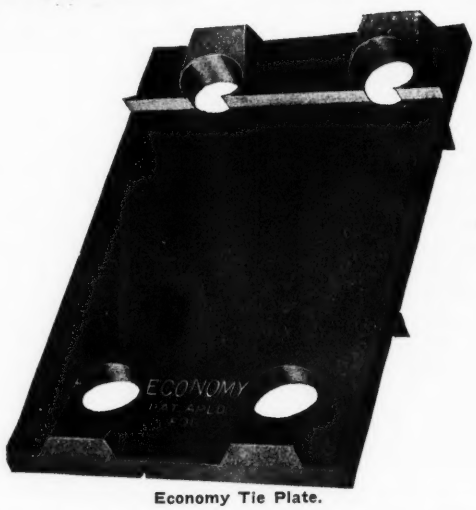
1. What is the best form of screw spike?
2. What is the best method for applying?
3. What is the comparative holding power of a screw and common square spike?
4. What is the relative holding power of screw and common square spike in different species of wood, on treated and untreated ties?
5. What is the best design of tie plate to use in connection with the screw spike?
6. Can a tie plate be rolled in compromise form to accommodate A. S. C. E. and A. R. A. sections of rail of the same weight per yard?

At the Coliseum, this month, Economy tie plates, which have been designed for use with screw spikes, as indicated above, will be exhibited by Spencer Otis Co These plates are constructed to insure a perfect bearing for the flange of spike to both the rail and the plate and to furnish a reinforcement back of the spike in order to prevent bending, which would be caused by a lateral movement of the rail. This construction also minimizes spike cutting, which is caused by running rail, and at the same time the construction makes it necessary to drive the spike vertically.

One of the first difficulties encountered was the manufacture of these tie plates, but this has been successfully done at the Portsmouth mills of the company mentioned above. One illustration shows the Economy No. 9-R tie plate that embodies the requisite principles of design. The plate has a strong main body, having a retaining shoulder wtih elevated bosses, that are rolled on the same angle as the flange of the rail, and also bosses on the outside end of the plate. It may be said again that these bosses provide a bearing for the screw spike, and also prevent bending and cutting of the screw spike. The spike holes in the bosses serve as guides for boring ties after the plates are in position under the rail.

The tie plates are rolled from open hearth steel, the bottom surface having four longitudinal or two transverse flanges or without flanges, as desired. The punching of these tie plates may be for 2, 3 or 4 holes, to meet any special requirements in this direction.

Tie Plate and Screw Spikes.



Economy Tie Plate.

Relative to the strength and holding power of the screw spike, it should be said that tests have shown the holding force of screw spikes to be from two to three times as great as that of common spikes. The problem was to reduce the weight of the spike and yet to maintain the same maximum strength and holding power without impairing efficiency. In the solution of this problem, it will be realized that the support given the spike by the special design of Economy tie plate has made it possible. In conclusion, we should add that the Economy plates have been designed to accept both A. S. C. E. and A. R. A. sections of rail. Spencer Otis Company's exhibit at the Coliseum, Spaces 121-141, this year will be interesting to those that have to do with modern track construction. One can certainly find these tie plates to suit almost any condition now before American railroads.

Center Dump and Controllable Discharge Buckets.

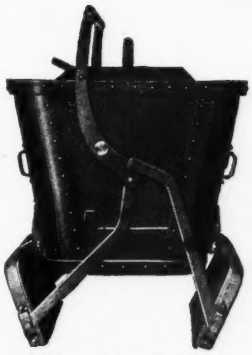
The center dump bucket, known as Doud's "Acme," is used for foundation and other work when it is not necessary to control the discharge of material. The body of the bucket is made of heavy steel plates riveted together with rounded corners to strengthen the construction and aid discharge of material. The bottom is closed by two oppositely hinged doors.

To discharge the bucket, the operating lever is given a slight upward pull which unlocks the lever and permits the doors to swing outward. The contents are, therefore, discharged vertically from the center, eliminating side splash or side jumping.

The device for opening and closing the doors is very simple. It consists of steel levers operating on the pivot principal, having no slides, springs or other complicated parts to become clogged or get out of order. The pivot points are so arranged that when the bucket is closed, the doors are securely locked and the heavier the load the more effective the lock. The shape of the bucket, together with its simple opening at the bottom and straight sloping sides which do

Controllable Discharge Bucket

Doud's controllable discharge bucket is designed especially for transporting and depositing concrete in forms where the work is such that the material must be under constant and perfect control. The operating mechanism of this bucket is



Center Dump Bucket.

so designed that the gates open and close symmetrically. This enables the operator to deposit material in the exact position desired because the bucket dumps directly from the center owing to the symmetrical movement of its gates. It also permits him to perfectly control the quantity of material deposited and allows just the right amount to be discharged.

The gates of the bucket can be opened or closed in any width from 1 to 16 in. and at the same time hold the material under perfect control.

The location of the operating lever represents another very important feature in the construction of Doud's Controllable Discharge Bucket. This lever rests at the top of the bucket instead of at the bottom, which is the construction employed in buckets made by other manufacturers. The high position of this lever permits the bucket to be lowered well down into the form before the gates are opened and material discharged. This is especially important in handling sloppy concrete. It absolutely prevents side splash and the consequent waste of material therefrom. But this feature is entirely void in buckets where the operating lever is placed at the bottom of the bucket. Also by placing the lever at the top of the bucket, it is easy of access at all times.

The controllable discharge bucket is designed with large opening at the bottom and straight slopping sides which do not support cross rods or other parts that tend to hinder the discharge of material. It is, therefore, clean and quick dumping.

Self-Supporting Bncket

The controllable discharge bucket is also built self-supporting. It requires no special platform and is also made for trucks. The simplicity lies in the lever mechanism. These buckets are manufactured by the Acme Equipment & Engineering Co., Cleveland.

Universal Carrier Base

The Universal carrier base, manufactured by the W. K. Kenly Company, is presented for the attention of signal engineers and supervisors as a substitute for the old wooden block which has been used for holding pipe line carriers to their foundations. The illustration shows the device adapted to six-way pipe line carriers, but it is also made in one, two, three, four-way units.

The slots for the anchor bolt are made long, so that the base may be fastened in almost any position on the foundation blocks, and may be shifted laterally if necessary. The device is made in malleable or cast iron.

The Universal carrier base may be applied or removed quickly. By means of the lap joint on the ends any number of pieces may be put together and the lap protects against twisting. It is not necessary to have the joint come on the foundation block.

Judge William J. Calhoun

Mr. J. W. Duntley, president of the Duntley Manufacturing Company, makers of the Rockford car, the board of directors, and employees of the company, gave an informal dinner to Judge William J. Calhoun, the newly appointed minister to China, at the Union League Club, Chicago, Tuesday evening, March 8.

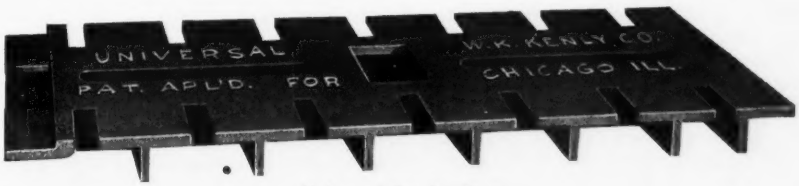
The affair was entirely an informal one and tendered to Judge Calhoun by the employees of their appreciation of him as one of their employers, he being one of the board of directors of the company. The speeches were few, and of an informal nature. Mr. Duntley acted as toastmaster, and presented Judge Calhoun in a short speech, in which he said:

"Judge Calhoun, you are going to a far-off land and I take peculiar pleasure in presenting to you this little token of the esteem and regard in which you are held by the Duntley Manufacturing Company, its officers and employees. It is a watch fob set with Chinese jade, and may its mission be ever to recall to your mind this scene and the feeling that prompts us in presenting it, and serve to remind you that 'The distant far, still to memory dear.'"

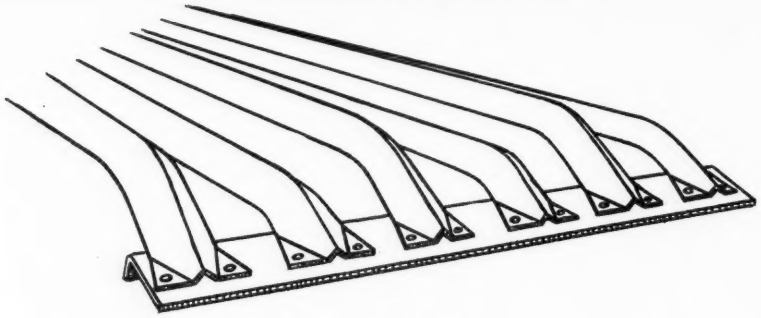
In the course of his reply Judge Calhoun said:

"When I am in a strange land and among strange people, in fact all the balance of my life, I shall always have the most pleasant recollections of this evening, and I am delighted to see so many bright young men gathered around this table. When Mr. Duntley inaugurated the enterprise a year ago I do not think he had more than a half dozen men in his employ, and he was in a little office over on Dearborn street. The enterprise has since developed so rapidly that it commands the assistance of the large organization which is represented here tonight.

"Behind every manufacturing and commercial enterprise are several forces, particularly in the manufacture and sale of what may be called a specialty. In the first place there is behind all the forces the inventor. His ingenious mind produces the article; he studies the ned of the public, and he tries to invent and produce something to meet that demand, so that he is after all the beginner of every movement of this kind, and always the important element in its success. After he produces a thing that the public wants, then the next thing is to introduce it to the public. Now, this business, which has grown so rapidly that it has been a surprise to Mr. Duntley and everybody connected with it, is divided into two departments,—first, the cleaner, with which perhaps most of you are identified. Sitting over there is Mr. Smith, whose brain conceived the machine in all its parts and prepared it for the use and application to the wants of men."



Universal Carrier Base.



Century Cattle Guard.

Century Cattle Guard

The Century Materials Company has recently completed its new plant at Chicago Heights, with greatly increased capacity, and improved manufacturing and shipping facilities.

The well-nigh universal practice on American railroads is to use wooden bars or slats parallel to the rails, and secured together by steel bolts, strips or other fastenings. In the Century Guard, which this company manufactures, no innovation upon standard practice is observed, except that the wooden longitudinal bars are replaced by metal, the guard being constructed of 1½ in. x 1½ in. x ⅛ in. angle iron, the ends being properly drop formed so that the danger of dragging brake-beams, etc., becoming engaged in the guard is eliminated. The length and width of the guard can be adapted to meet the particular needs of standard and narrow gage lines.

The company has recently published a bulletin on "Cattle Guard Practice," which it will gladly send to those interested, on application to its Chicago office, room 710 Watson building, Chicago.

Hardening of Concrete

This question was referred to our committee in consequence of a letter to the association from the Aberthaw Construction Co. of Boston, which pointed out the great need of reliable information on the rate of hardening of concrete at low temperatures, as an aid to builders in determining the time for safe removal of forms and supports. The great importance of this to the art of concrete construction and to the cement industry is, of course, evident. The difficulties in the way of carrying on experiments which will give results of practical value are very great, as shown by our abstract of the literature of the subject, attached to this report. An editorial article in the "Engineering News," December 3, 1908, on "Relation of Temperature to Removal of Concrete Forms," points out the scarcity of information on this question, and gives the following suggestions as to the line which should be followed in further investigations:

"As the time of removing forms is dependent on the strength of the concrete, the proper test to make in the investigation proposed is the effect of temperature on strength, either tensile or compressive, in a given time.

"For instance, it may be found that a certain concrete at 70° reaches a compressive unit value of 1,500 lbs. in 48 hours, a strength deemed sufficient for safe removal of forms.

"The proper way to determine the time of removal at other temperatures would be to determine by tests the time necessary for the compressive unit strength to reach 1,500 lbs. at each of the desired temperatures; or at least, by means of several specimens from the same mix, to determine a strength-time curve from which can be computed the time when a 1,500-lb. strength may be expected. It may be found, then, that for fixed conditions of mix and material there can be deduced some relation between strength and temperature which can be used in construction. Such relation need not be rigid, because the large margin of safety allowed in the assumption of the proper unit value will take care of any but most unexpected variations from the deduced rule. It is to be hoped that such tests will be undertaken, for the establishment of some scientific basis for removal of forms will add to the fast-growing rational design and construction in concrete."

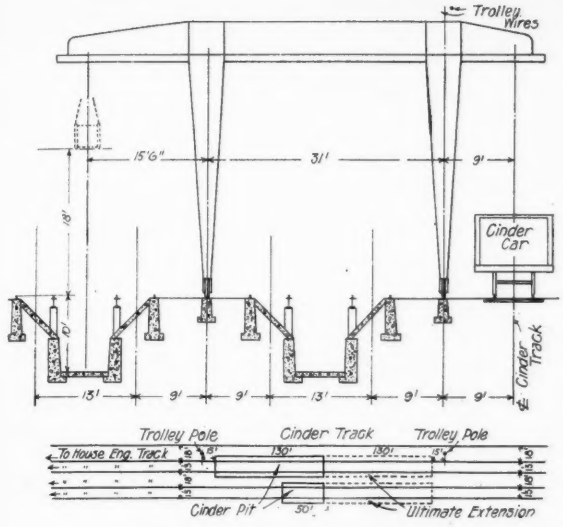
The Aberthaw Construction Co. have themselves carried on some experiments on this question. (See abstract.) These consisted in exposing briquettes, neat and with 3 parts sand, to air at 72°, 41°, 34°, and -7°, the cold tests having been carried out at the Quincy Market Cold Storage Warehouse, Boston. These show that at 28 days the briquettes at 41° and 34° showed better strength than those at 72°, doubtless owing to the more rapid drying out of the latter.

For fair comparison, test pieces at the various temperatures must be kept uniformly moist, either in water or in moist air in a closed box. In addition to neat and sand tests, concrete of average composition, perhaps 1:2:4 and 1:3:6, must also be tested, and this can be done only in comparison of cubes of at least 3-in. size.

This work can be carried on only at laboratories provided with compression apparatus and situated near cold storage warehouses at which permission to store test-pieces can be secured. This investigation will be taken up at once by the committee, and an effort made to obtain the assistance of laboratories in the principal cities, such as those of the Aberthaw Co. of Boston, the Department of Public Works at Philadelphia, the Hunt Engineering Co. of Chicago, and Mr. Clifford Richardson of New York.—From the progress report of the Committee on Technical Research of the Association of American Portland Cement Manufacturers, from the Concrete Review.

Florida is about to get its first practical experience of the results of National Forest administration. A reconnaissance survey of the Choctawhatchee Forest, which was put under control of the Department of Agriculture in November, 1908, by Presidential proclamation, is now being made by a force of Forest Service experts. This survey will furnish information in the light of which use of the forests can be promoted through properly regulated timber cutting, through turpentining under the cup-and-gutter or the cup-and-apron method, and through grazing, without harm to the permanent value of the forests. Florida was the first State east of the Mississippi to have a National Forest.

The Choctawhatchee Forest containing approximately 467,606 acres, is located in the western part of the State, along the Gulf, in Walton and Santa Rosa counties. The Ocala Forest, embracing some 207,285 acres, lies in the central part, the greater portion of the Forest being in Marion county, with a small fraction in Lake. The two Forests were placed under administration November 1, 1909.



Ash Handling Plant, Vandalia R. R.

New Terre Haute Shops, Vandalia Railroad

About a mile northeast of the present Vandalia shops at Terre Haute, Ind., a site for a new terminal has been located. The present shops have not the capacity to handle satisfactorily the locomotive and car repairs, and on account of limited space of the old site the officials have contemplated a new plant instead of reconstruction of the present one.

One of the accompanying drawings illustrates a very comprehensive layout. Work has been started and the roundhouse is nearly completed.

It will be noted by reference to the layout that the present engine house consists of twenty-five stalls, with provision for an ultimate extension to forty-seven stalls. The erecting shop is to have a capacity of twenty-four engines, with an ultimate capacity of considerably more than twice this number. The scheme of liberal allowance for future extensions is carried throughout the plans.

Cinder and inspection pits have been given special attention with the result that, as at present arranged for, delays due to incapacity, so manifest in a large number of terminal installations, will be entirely avoided.

An ash-handling plant, illustrated herewith, has been designed with the same care given the other features, and it is expected that the plant will be a model one in all respects.

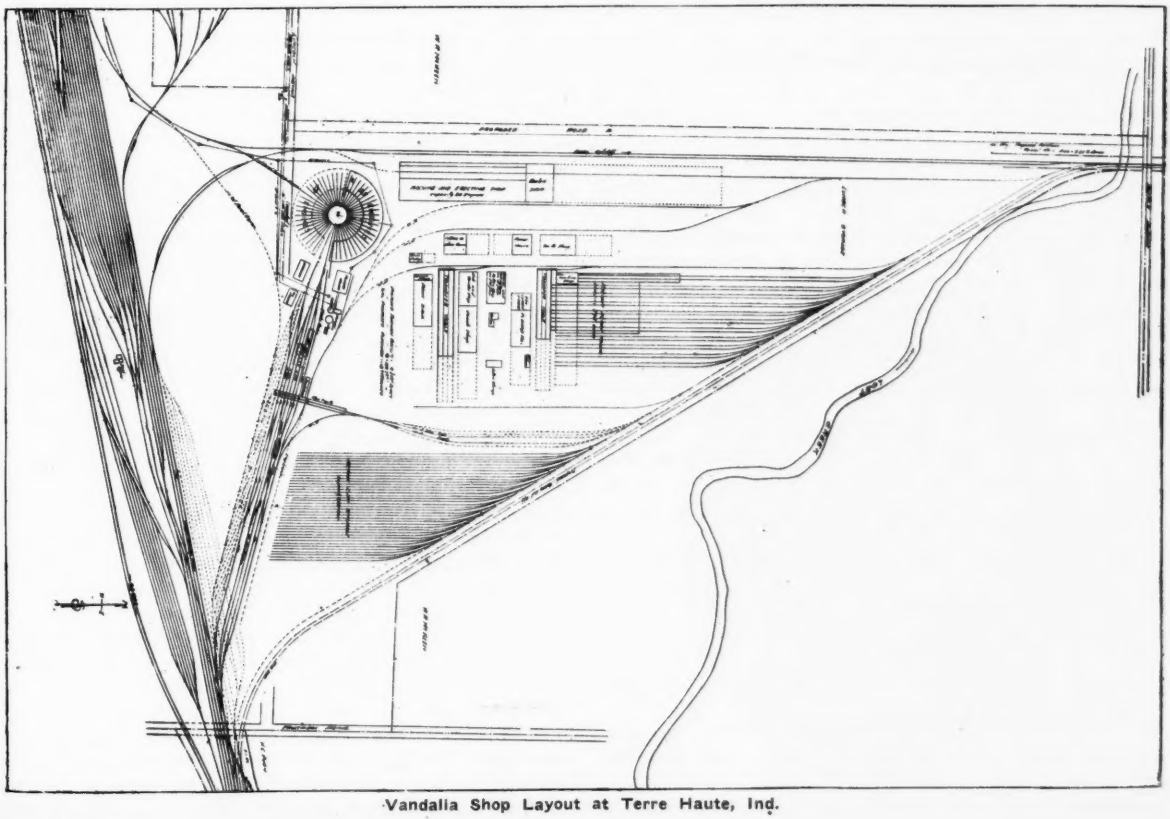
The equipment of the yards includes a Booth water softener of large capacity.

We are indebted to Mr. W. C. Arp, superintendent of motive power, and Mr. R. C. Rochester, engineer maintenance of way, for the drawings reproduced in this article.

Borrowing Forest Trees

The enterprise of German foresters and the importance of tree planting for forest purposes are strikingly shown by two items of news which come, the one from Montana, the other from Ontario. It is reported that a demand has developed for Montana larch seeds to be used by German nurserymen; while white pine seedlings are to be imported from Germany by the town of Guelph, Ont., for planting a 168-acre tract of land belonging to the municipality.

The Germans recognize that the introduction into their forests of valuable trees native to other countries may be decidedly to their advantage. Although as a rule the forest trees best adapted to each region are those which naturally grow in it, there are many exceptions. Norway spruce and Austrian and Scotch pine have been carried from their native home to other parts of Europe and to America and have been



Vandalia Shop Layout at Terre Haute, Ind.

found well worth the attention of the grower of timber. Several of our own species have met with favor in Europe and flourished there, such as the Douglas fir, black walnut, and others. The Australian eucalyptus is proving a great find for America and South Africa.

Our own white pine long ago crossed the Atlantic in response to the needs of Europeans, whose forests are comparatively poor in tree species, and is now grown commercially on such a scale that when it is wanted for planting in its own native habitat the German nurseryman is often ready to deliver young plants here for a lower price than our own nurserymen will quote. Now the Germans are going to try the Western larch also. The request from the German nurseryman instructs the collectors to gather the choicest seeds when ripe this fall. One nurseryman on Flathead Lake offered to exchange larch seeds for seeds of desirable German shrubs, which he intends to cultivate and sell in America. In the same region, four or five months ago, foresters of our own Department of Agriculture gathered seed for use in the neighboring Lolo Forest, where a new forest-planting nursery was begun last year.

The objects of the Guelph planting are, according to local accounts, to protect the town's water scource by a forest cover over its springs in the hills, to make a beautiful woods for a public park, and to provide for a future timber supply as a municipal asset. In foreign countries, forest tracts are often owned and managed by towns and cities as a paying investment and to insure a permanent supply of wood for local consumption, but in America planting by municipalities other than for parks and for watershed protection has scarcely been thought of. The kinds of trees to be grown in the Guelph park have already been decided upon by the Ontario Agricultural College. The proposed reforestation promises to be of so great economic and sanitary value that the estimated cost of $8 per acre for importing and planting the seedlings and caring for the growing trees is regarded as well worth while.—Forest Service.

Pennsylvania Tree Planting

The Pennsylvania Railroad Company has planted 3,482,186 trees since it undertook forestry work on a comprehensive scale. This is brought out in a report just issued by the forester of the railroad. In 1909 alone more than a million trees were planted on tracts of land along the company's right of way.

Prior to last year, the Pennsylvania's forestry operations were confined to a limited area between Philadelphia and Altoona. In 1909, however, 7,800 trees were planted near Pomeroy, Pa.; 188,200 in the vicinity of Vandyke, Pa.; 35,000 near New Brunswick, N. J.; 352,000 near Eyer, Pa.; 30,000 on the right of way near Metuchen, N. J.; 161,825 at Denholm, Pa.; 204,500 at Conewago, Pa., and 74,500 at Parkton, Md.

The total number of plants shipped from the company's forest nursery at Morrisville, Pa., was 1,240,381. There are at the present time in the nursery, trees for forest planting ranging in age from eight months to six years. During the year five bushels of acorns were planted in their permanent places as an experiment.

A special effort was directed last year to growing ornamental shrubbery for use in parking the lawns around stations and unoccupied places along the roadway. To save the time required to grow these from seed, 6,000 plants were imported from France. They were placed in beds at the company's nursery at Morrisville. Part of them will be ready for transplanting this year, and the remainder in 1911. There are some 56,000 trees and shrubs which are now being held in nursery rows until they become large enough for ornamental trees.

Indicative of the scope of the Pennsylvania Railroad's forestry operations—the largest ever undertaken by any corporation—is the following table showing the planting done in the last eight years:

Year	Number of trees planted.
1902	13,610
1903	43,364
1904	223,656
1905	597,165
1906	801,625
1907	448,226
1908	300,530
1909	1,054,010
	3,482,186

Under the direction of the forester, a large pressure treating plant has been in operation at Mt. Union, Pa., since July 1, 1909, and a small experimental non-pressure plant has been installed at Greenwich Point, Philadelphia. A second pressure plant is now under construction at Greenwich Point, and with all three in operation the total output will be about a million and a half ties per annum. There have been creosoted up to December 31st at Mt. Union, 135,727 No. 1 and 46,625 No. 2 ties; 80,000 board feet of bridge timbers; 25,000 lineal feet of trunking and capping for signal wires, and 25,000 wood paving blocks. Reducing all of this material to board feet gives a grand total of 7,861,000 feet of timber treated at Mt. Union. The non-pressure plant at Greenwich Point has turned out ties and timber equivalent to 432,000 feet, also 5,000 fence posts and 25,000 paving blocks.

Mr. William McNab

Mr. William McNab, President of the American Railway Engineering and Maintenance of Way Association was born in Scotland 55 years ago. He is a son of the late Thomas McNab, and grandson, on his father's side, of the late William McNab, Curator and General Superintendent of the Royal Botanic Gardens, Edinburg, Scotland; and, on his mother's side, of the late James Haig Cobban, Collector of Her Majesty's Customs, Alloa, Scotland.

Coming to Montreal with his parents at an early age, he was educated at the McGill Model School and at the Montreal Collegiate School, and on graduating from the latter, in 1870, entered the service of the Grand Trunk Railway as an indentured pupil in the Engineering Department, and has since been continually connected with that great Corporation.

During this long period, Mr. McNab has had charge of the surveys for, and construction of, many of the new Lines which eventually became part of the System, as well as having been closely identified with the design and Superintendence, both in new construction and maintenance of most of the important works that have been the means of transforming the then Grand Truk Railway into the great modern system that it is at the present day. That these works were many and varied in character goes without saying, and the opportunities for gaining experience afforded on a road which has grown from small things to a System of such magnitude and international importance as the Grand Trunk now is were not few nor insignificant.

Previous to 1875 Mr. McNab was engaged with the then Chief Engineer upon detail matters connected with the works of the International Bridge, then in course of construction across the Niagara River between Buffalo, N. Y. and Fort Erie, Ont., upon the location and construction of the Lewiston and Auburn Railroad in Maine, including its bridge work: the construction of the Union Station buildings and general terminal facilities at Toronto, and the then new erecting and machine shops at Stratford, Ont. He has also superintended

the various works connected with the erection in iron of all the Howe truss bridges on the Railway, the construction of the new train ferry docks at Point Edward, Ont., and Fort Gratiot, Mich.; and the methods adopted for the practical work in, narrowing the old broad gage of 5½ feet to the present or standard gage.

Between 1875 and 1885, inclusive, after having passed an examination before the Province of Quebec Board of Examiners for study of land surveying, he was engaged for several years almost exclusively upon Grand Trunk Railway surveys, acting during that period as Engineer of surveys and levels on upwards of 400 miles of Grand Trunk Railway Lines for projected revision work; Engineer of Construction of double tracking between Scarboro, Ont., and Toronto, Ont., of York Yard Terminals and engine houses, and construction of portions of lines in the State of Michigan and Provinces of Ontario and Quebec, now merged into the Grand Trunk System.

Between 1886 and 1896 inclusive, he had charge of general engineering work and maintenance of way, including control of contruction of the terminal station at Montreal; the subway under the freight and terminal yards, Wellington Street, Montreal; Back Cove draw bridge and approaches, Portland, Maine; and the design and construction of masonry and other general structures of the Railway.

From 1896 to 1907, he superintended the drafting room and assisted in the replacing of the single track Victoria iron tubular bridge across the River St. Lawrence, at Montreal, by the present double track steel trusses. In 1907, Mr. McNab was appointed Principal Assistant Engineer of the whole System, covering 4645 miles.

The history of Mr. McNab's life is really a story of the development and evolution of the technical side of Railway management that has made the physical status of the Grand Trunk Railway the admiration of those who have followed the trend of events in Railway engineering.

Mr. McNab had ample opportunities of extensive travel, and the knowledge acquired by such opportunities was used to advantage. He is a member of the American Society of Civil Engineers, as well as of the Canadian Club, and the Canadian Society of Civil Engineers. He was a member of the Council of the latter body in 1903 and in 1907, and is at present a member of its Standing Committees on Transportation, Rail and Roadway respectively. He is a charter member of the American Railway Engineering and Maintenance of Way Association, and in this connection, was the First Vice Chairman of the Committee on Graduation, (afterwards Roadway) becoming Chairman in 1902. In 1904 he was appointed Chairman of a new Committee, that on Economics of Railway Location, and in 1905 was elected a Director of the Association. In 1907 he was elected Second Vice-President and became First Vice-President in 1908, and in the same year succeeded to the office of President made vacant by the death of the late Walter G. Berg. In March 1909 he was elected President of the Association.

Mr. O. F. Barnes.

Mr. Orgood Frost Barnes, division engineer, Erie R. R. Susquehanna, Pa., was born in Chelsea, Mass., August 24, 1875, and graduated from Chelsea High School, June, 1892. Prepared for Harvard Law School but following brief experience in business he decided to take up civil engineering and studied at the Mass. Institute of Technology.

He was first employed on engineering work by the Metropolitan Sewerage Commission of Mass., March 1, 1895 as rodman, continuing in service of that Commission next 6 months as rodman, transitman and eng. inspector in various locations about Boston during construction of the Metropolitan Sewerage System. He was Asst. Auditor, Metropolitan Water Board from Sept. 1st to Nov. 30th, 1895, returning to Sewerage Commission Dec. 1st, as Asst. Transitman on preliminary surveys for Neponset Valley sewer in Hyde Park, Mass.

He entered railroad service Feb. 1, 1896 as rodman, Boston & Maine R. R. at Boston, Mass., and after working as draftsman and transitman was transferred at own request from Engineering Dept. to Road Dept of that road in Oct. 1897. After next 8 months service as Laborer in that Dept. acquiring practical knowledge of details of M. of W. work he served successively in all intermediate subordinate positions resigning as Asst. Roadmaster (Acting), Eastern Division, Portland, Me., in Dec. 1900 upon death of father to attend to personal matters.

Being otherwise employed, meanwhile he returned to railroad work July 1, 1902 as Asst. Engineer, Pittsburgh, Shawmut & Northern R. R., being employed during that summer at Angelica, N. Y., as Resident Engineer in charge of restoring some 5 miles of washed out road, afterward having charge of inspection of concrete masonry construction and later on, of all track laying and ballasting on some 35 miles of new construction. Was transferred as Asst. Engineer from the Engineering Dept. to the M. of W. Dept. of same road in July 1903, and appointed General Roadmaster, succeeding to the position and duties of Engineer M. of W. Sept. 1., 1903.

He was appointed Division Engineer, Erie R. R. at Rochester, N. Y., April 20th, 1905, and transferred to present position, Division Engineer, Deleware and Jefferson Divisions of this road with headquarters at Susquehanna, Pa., June 1st, 1908.

Obituary.

Mr. James Keys died at Excelsior Springs, Mo., December 27, 1909, aged 36 years. The funeral was held from his parents' home January 1, 1910. Interment in Riverside Cemetery, Norristown, Pa.

James Keys was born at Harmanville, Plymouth Township, Montgomery Co., Pa., and was the eldest son of George W. and Emma Kirk Keys. His early education was received in the public schools of Conshohocken, Pa., and he graduated with honor June, 1892, from the High School. He entered Lehigh University the following September, graduating as Civil Engineer June, 1896.

After leaving Lehigh, he secured employment the following week with Pencoyd Iron Works in the Bridge and Construction Department at Pencoyd, Pa., where he remained two

James Keyes.

years. He then engaged with the Keystone Works at Pittsburg, remaining one year. Desiring a broader field of labor he secured the same with the Great Northern Railway Company at St. Paul, Minnesota, as Assistant Engineer in their Bridge Department. Continuing here for two years, he learned much relating to the practical construction of bridges and buildings.

To use his own language: "I had now secured sufficient practical knowledge to feel confident of my ability, and therefore engaged with Mr. J. B. Berry, Chief Engineer of the Union Pacific Railroad Company, at Omaha, Neb.," with which Company he remained, in charge of bridge design and construction, until time of death.

James Keys was of a retiring disposition; even of temper and with a determination to accomplish whatever he set out to do. He had a strong sense of justice, but resented bitterly any treatment which he considered unfair. He was thorough; he was reliable. The confidence placed in him by his superiors was never misplaced.

He desired to be a good engineer, and how well he succeeded is attested by the advancement he made in his profession. He rose from a young engineer to be the Bridge Engineer of the Union Pacific Railroad, one of the greatest railroad systems in the country, and he attained all this at an age when most men are content to secure honors and position much less responsible than his.

Personals.

Mr. F. E. Whitcomb has been appointed engineer maintenance of signals of the Boston & Albany, with office at Boston, Mass., succeeding Mr. J. M. Fitzgerald, promoted.

Mr. Louis Yager has been promoted division engineer of the Northern Pacific, in charge of engineering matters on the lines east of Mandan, N. Dak., with office at St. Paul, Minn.

Mr. G. M. Ball, Jr., supervisor of Division No. 9 of the Pennsylvania Railroad, has been transferred to Division No. 7, on the Middle division, with office at Huntingdon, Pa., succeeding Mr. M. I. Ward, deceased. Mr. J. O. Heap succeeds Mr. Ball, with office at Haddonfield, N. J.

Mr. J. M. Fitzgerald, engineer maintenance of signals of the Boston & Albany, at Boston, Mass., has been appointed assistant signal engineer of the New York Central & Hudson River and the Boston & Albany, with office at Albany, N. Y., succeeding Mr. W. A. Peddle, resigned to go to another company.

Mr. Lewis Kingman, assistant chief engineer of the National Railways of Mexico, the Mexican International and the Interoceanic at Mexico City, Mex., has been appointed engineer maintenance of way, with office at Buenavista, succeeding Mr. C. G. Delo, resigned. Mr. H. B. Reese, division engineer at Chihuahua, succeeds Mr. Kingman, with office at Mexico City.

Mr. W. C. Smith, engineer maintenance of way of the Northern Pacific lines east of Paradise, Mont., at St. Paul, Minn., has been appointed chief engineer of maintenance of way, with office at St. Paul.

Mr. M. H. Wickhorst, engineer of tests of the Chicago, Burlington & Quincy, with office at Aurora, Ill., has been granted a leave of absence for one year to become chief chemist in charge of rail tests by the American Railway Engineering and Maintenance of Way Association. Mr. W. A. Derby succeeds Mr. Wickhorst.

Mr. J. E. Schiller has been appointed a roadmaster on the Minidoka Roadmaster's District (Idaho division) of the Oregon Short Line, with office at Pocatello, Idaho, succeeding Mr. Frank McGonigle, resigned.

Mr. T. J. Wyche, division engineer of the Western Pacific at Elko, Nev., has been appointed chief engineer, with office at San Francisco, Cal., succeeding Mr. Virgil G. Bogue, retired.

Mr. J. W. Stone has been appointed division engineer of the Philadelphia division of the Pennsylvania Railroad, with office at Harrisburg, Pa., succeeding Mr. G. H. Brown, granted leave of absence. Mr. N. B. Pitcairn, assistant supervisor of Division 6, on the Middle division, has been appointed supervisor of Division 1, on the Conemaugh division, with office at Vernon Pa., succeeding Mr. H. C. Bolenius, transferred; Mr. E. C. Silvius succeeds Mr. Pitcairn, with office at Mifflin, Pa. Mr. T. K. Minsker has been appointed assistant supervisor of Division 13, on the Pittsburgh division, with office at Pittsburgh, Pa., succeeding Mr. R. A. Klein, promoted.

Mr. D. S. Rice has been promoted supervisor of signals on the Buffalo division of the Lehigh Valley, to succeed Mr. Wm. H. Dewey, who has resigned. Mr. Rice was formerly supervisor of signals at Weatherly, Pa.

TECHNICAL DICTIONARY, published by the McGraw-Hill Book Company, New York. Vol. V., 870 pages, 4x7 ins., illustrated, $4.00 net. Vol. VI., 796 pages, 4x7 ins., illustrated, price, $3.00 net.

This illustrated technical dictionary is compiled in six languages: English, German, French, Russian, Italian and Spanish. Valume 5 covers railway construction and operation and Volume 6 covers railway rolling stock.

You will realize the value of a technical dictionary if you attempt to translate a technical article by means of a college dictionary for literature. The combination of words for technical expressions is seldom given in the ordinary dictionary that we use.

There is another volume to the dictionary. Many foreign or European constructions are illustrated. For instance we are now considering screw spikes and special tie plates for same and you will find illustrations of same in this dictionary.

The Indianapolis Switch & Frog Company, Springfield, Ohio, issued passes to the R. N. R. Railway frog exhibit, "The Manganese Line," at booth No. 182, Coliseum, Chicago, from March 14 to 19.

Fairbanks, Morse & Co. have recently issued a very interesting and complete catalogue on hydraulic, ball and roller bearing and compound jacks. The new forged steel hydraulic jacks, their construction and adaptability to various classes of work, are described in detail. This type of jack incorporates all of the finer features of the old style hydraulic jacks, the imperfections and troublesome features being entirly avoided.

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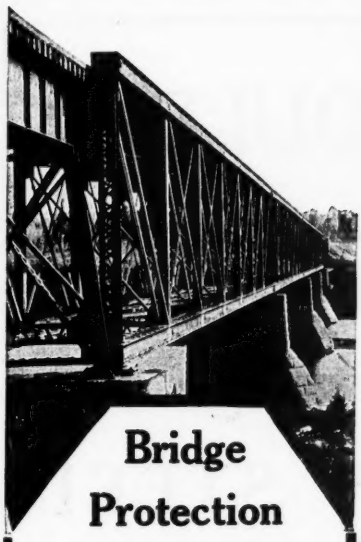

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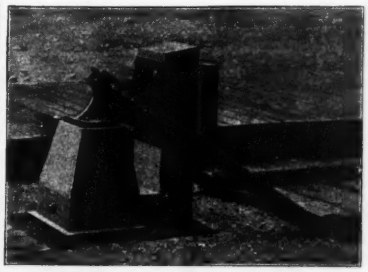

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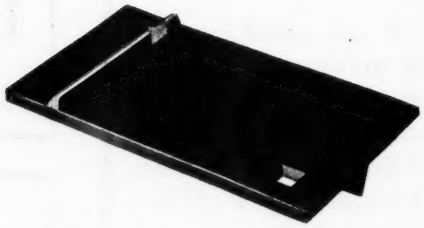

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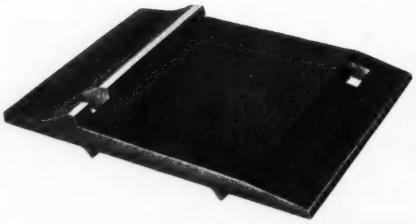

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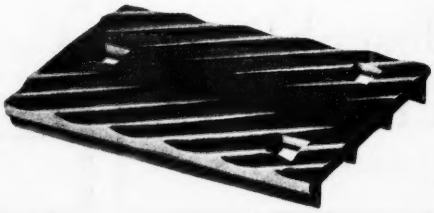

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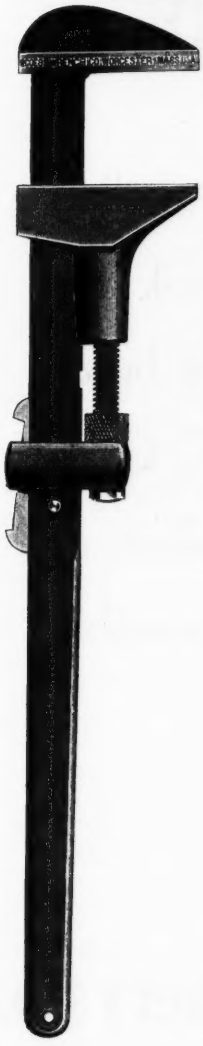

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Type Z left hand.

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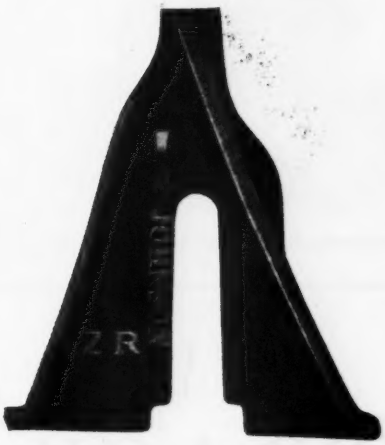

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Type M	for rail 12 - 45 lbs.	if not over 3½ inches high	20 Ton Locomotive	2 inches	30
" B	" " up to 80 "	" " 5 " "	50 " "	3¼ "	110
" A	" " " " 100 "	" " 5½ " "	80 " "	3½ "	145
" Z	" " " " 100 "	" " 6 " "	100 " "	3½ "	165
" AA	" " " " 105 "	" " 6 " "	200 " Wreck Outfit	7½ "	275

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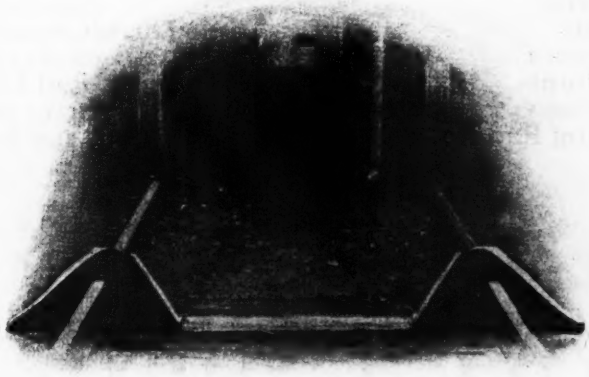

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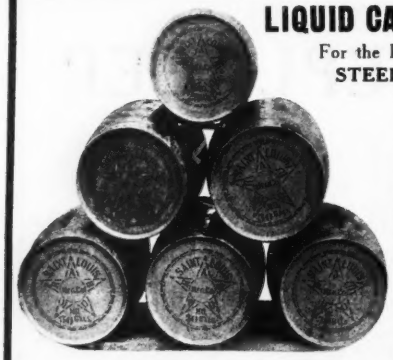

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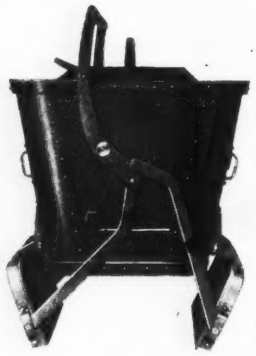

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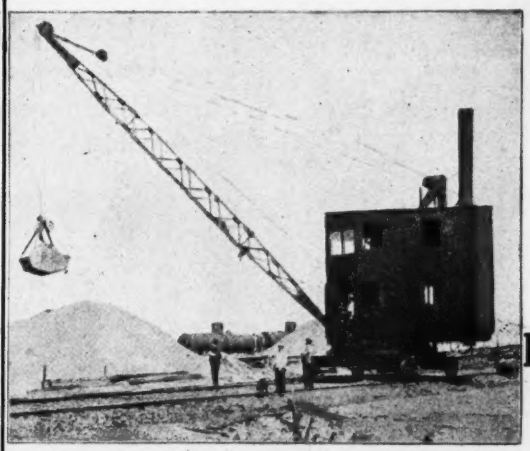

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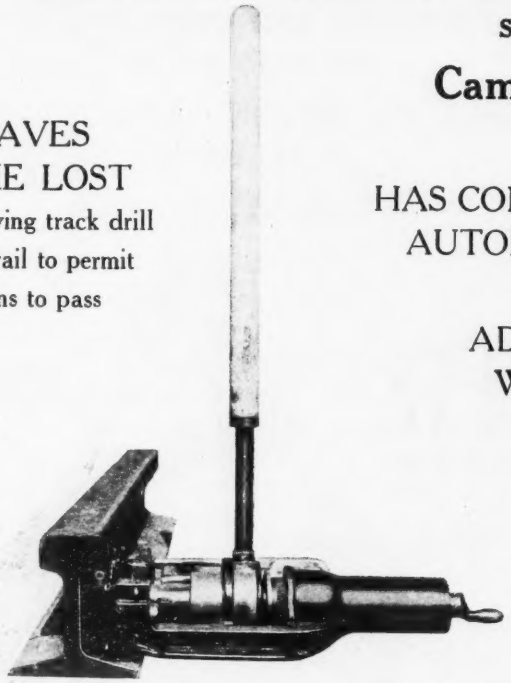

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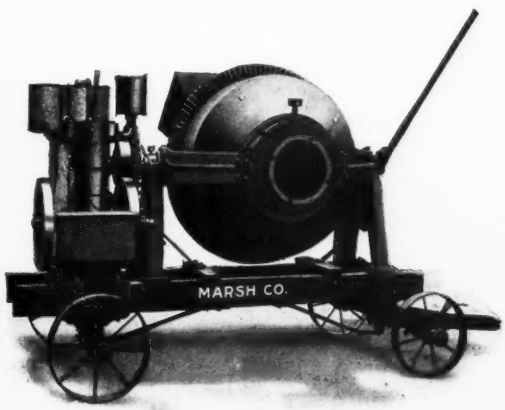

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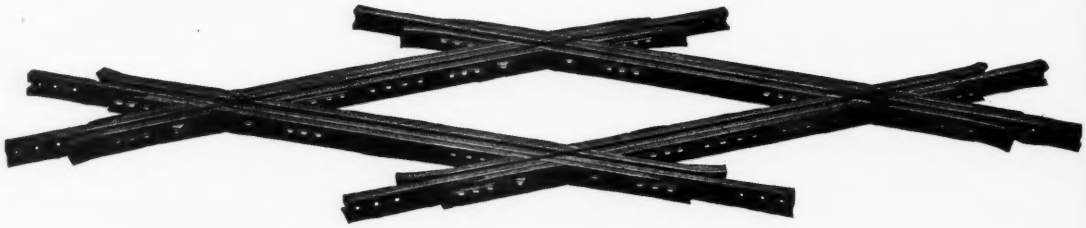

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